APPENDIX A

ARSYNCO, INC.

GEOLOGIC CONCEPTUAL SITE MODEL

2014

GEOLOGIC CONCEPTUAL SITE MODEL
ARSYNCO, INC.
(JMC, 2003 & JMC, 2013)

1.0 GEOLOGY

The following provides the geologic Conceptual Site Model (CSM) for the Arsynco Site.

1.1 Bedrock Geology

Drake et al. (1996) indicate that the Arsynco site, the hills of Carlstadt to the northwest and the Meadowlands to the east and southeast are all underlain by the Passaic Formation of Olsen (1980), which is a member of the Newark Supergroup. The Passaic Formation is further subdivided into different lithologies (Drake et al. 1996). Immediately underlying the Arsynco site and the highlands to the west is a sandstone lithology (JT_Rps, see Figure B-3). Drake et al. (1996) describe the sandstone lithology as "…interbedded grayish-red to brownish-red, medium- to fine-grained, medium- to thick-bedded sandstone and brownish- to purple-red coarse-grained siltstone". Some of the sandstone beds are highly fractured and serve as the primary source of ground water in this region (Carswell 1976). To the east, most of the Meadowlands is underlain by a sandy mudstone lithology (JT_Rpms, see Figure B-3). Drake et al. (1996) describe the sandy mudstone lithology as "…reddish-brown to brownish-red, massive silty to sandy mudstone and siltstone, which are bioturbated, ripple cross laminated, and interbedded with lenticular sandstone."

The depths to the top of bedrock range from a few tens of feet in the uplands along the western boundary of the Hackensack lowlands to more than 250 feet in areas along the western margin of the glacially scoured trough which forms the lowlands (Stanford 1993). Two deep wells located just south of the Arsynco site indicate that bedrock surface lies at an elevation of approximately 220 to 230 feet below sea level (Stanford 1993).

1.2 Surface Geology

The surface geology in the region of the Arsynco site consists of glacial and glaciofluvial deposits and artificial fill (Stanford 1993). Figure B-2 provides a map of the surface geology in the site region compiled after Stanford (1993). As shown, the site is underlain by artificial fill material (a_f) and estuarine and salt marsh deposits (Q_m). The only exception may be a very limited area along the extreme western section of Tract 1, where deltaic sands and gravels were deposited into glacial Lake Bayonne.

The presence of the deltaic deposits (Q_{bn}) and the Moonachie Terrace Deposits (Q_{mt}) further north along the western boundary of the Hackensack River Valley (see Figure B-2) are expected to play an important role in the ground water flow in the region. The hydrogeologic significance of the deltaic deposits is discussed in Section 4.5, Hydrogeology, below.

The majority of the surficial deposits in the Meadowlands region are associated with a sequence of glacial lakes. These lakes formed between the retreating ice margin and the sequence of lowering spillways that controlled lake levels beginning with the terminal moraine at Perth Amboy and Staten Island. Figures B-3 and B-4 are geologic cross-sections (cross-sections BB' and DD' from Stanford 1993) illustrating the distribution of subsurface deposits in the region of the Arsynco site. The glacial lake bottom sediments clearly predominate in the Meadowlands region of the Hackensack River valley subsurface. The following sequence of glacial lake deposition follows Stanford and Harper (1991).

1.2.1 Glacial Lake Bayonne

The Late Wisconsinan ice sheet deposited a thin veneer of glacial till on top of the bedrock surface over most of study area. The till thickens to as much as 50 to 150 feet in the terminal moraine at Perth Amboy and Staten Island (Stanford and Harper 1991). A series of glacial lakes occupied the Meadowland lowlands as far southward as the terminal moraine at Perth Amboy once the ice began to retreat approximately 20,000 years before present (YBP) (Stanford and Harper 1991). The northern boundary of the lakes was the retreating ice margin. This margin was located well south of the Arsynco site during the earliest glacial lake stages. Hence, their deposits have no bearing on the Arsynco site local region.

The first expansive glacial lake was Lake Bayonne. The southern margin of glacial Lake Bayonne was the terminal moraine which runs southeast along northern Long Island, across Staten Island to Perth Amboy, and curves back to the northwest. Its northern boundary was the retreating ice margin, which roughly paralleled the moraine and retreated to the north-northeast. The Lake Bayonne lake-bottom deposits consist of reddish brown to gray varved silt and clay (Stanford 1993). The Lake Bayonne lake-bottom deposits extend, in the subsurface, as far north as approximately one mile north of Route 120. They range up to 160 feet thick in areas within the Meadowland lowlands.

Lake Bayonne drained southward over the terminal moraine at Perth Amboy. Sand and gravel of lacustrine-fan and deltas were deposited in the lake along its western boundary (Stanford 1993). The lacustrine-fan deposits consist of brown to reddish brown sand with some gravel and range up to 200 feet thick. The deltaic deposits consist of yellow to reddish brown sand with some pebble gravel and minor cobble gravel and can be as great as 50 feet thick. These sandy deposits are important to understanding the hydrogeology of the Arsynco site, as discussed in Section 4.5, below.

Drainage of Lake Bayonne began eroding the terminal moraine, cutting down into the lake-bottom sediments along what is now the Arthur Kill, which forms the western boundary of Staten Island. Diabase bedrock of the Palisades Sill was eventually encountered at the current depth of approximately 30 feet below sea level at Tremley Point as erosion continued in the Arthur Kill (Stanford and Harper 1991). This became the initial, stable level of glacial Lake Hackensack. Glacial Lake Hudson was also established at this time east of the Palisades sill.

Figure B-5 illustrates the topography in the vicinity of the Arsynco site. The locations of topographic cross-sections A_tA_t' and B_tB_t' are illustrated on Figure B-2. Figure B-5 is a NW-SE topographic profile projected along the line of Central Avenue in Carlstadt and extends through the Arsynco site to Berry's Creek. The elevation data were obtained from the Weehawken NJ-NY 7.5 minute quadrangle topographic map (USGS 1995). The steep slope along the western side of the profile indicates where the Passaic formation bedrock resisted glacial scouring. The sharp change to a shallow slope marks the contact between glacial till (Qt) and the deltaic sands and gravels (Q_{bn}) deposited in glacial Lake Bayonne (compare Figures B-5 and B-2).

The Lake Bayonne deltaic sands and gravels (Q_{bn}) were formed by drainage from glacial Lake Passaic through the gap in the highlands through which Patterson Plank Road runs toward the west. This drainage deposited its coarse sediment load into Lake Bayonne as the delta (Q_{bn}) and its finer-grained sediment load as density flows forming the varved lake-bottom deposits (Q_{bnl}, and later, Q_{hkl}). The gap through which drainage from glacial Lake Passaic occurred is clearly visible in the topographic profile in Figure B-5 (SW-NE).

1.2.2 Lake Hackensack

Water levels in both Lake Hackensack and Lake Hudson were initially identical, with drainage controlled by the bedrock elevation at Tremley Point in the Arthur Kill spillway. Stanford and Harper (1991) estimated the eustatic glacial rebound curve for the Hackensack River valley to be approximately 3.5 ft/mile due north based on Lake Hackensack deltas. Using this figure for glacial rebound, a depth range of 5 to 10 feet to the top of the Lake Hackensack clays (assumed to be the lake bottom), and the approximate 22 miles north-south distance between Tremley Point and the Arsynco site, suggests a minimum water depth of approximately 82 to 87 feet for the late stage of Lake Hackensack at the Arsynco site. Silt and clay are all that would be expected given this water depth. The Arsynco site, however, lies in close proximity to the highlands which form the western boundary of the Meadowland lowlands. Land elevation rises rapidly to the west of the site (Figure B-5).

When the ice retreat uncovered Hell Gate in the East River east of Manhattan, the water level in Lake Hudson dropped as it began draining to the northeast. This eventually established a level for Lake Hudson that was approximately 40 feet lower than the level in Lake Hackensack. Drainage from Lake Hackensack into Lake Hudson began to erode the lake bottom sediments to form the current Kill Van Kull along the north side of Staten Island. Eventually the erosion encountered the Palisades diabase at an elevation consistent with the Tremley Point spillway elevation along the Arthur Kill spillway. Thus, Lake Hackensack had two stable spillways, one to the south through the Arthur Kill and the other to the east into Lake Hudson through the Kill Van Kull.

A drainage-way to the north for Lake Hackensack was eventually established at Sparkill Gap as the glacier continued to retreat. Sparkill Gap is approximately 2.1 miles south of the Tappan Zee Bridge. This spillway allowed Lake Hackensack to drain into Lake Hudson. Stanford and Harper (1991) and Stanford (1993) suggest that this probably occurred sometime between 18,000 and 17,000 YBP. Sediment dams retained water in the northern parts of Lake Hackensack.

Water released from these bodies carved channels into delta deposits when the dams breached. These channels provide geomorphic evidence that Lake Hackensack drained into Lake Hudson through the Sparkill Gap (Stanford and Harper 1991).

1.2.3 Post-Glacial Deposits and Erosion

Drainage of Lake Hackensack to the north through Sparkill Gap exposed the lake-bed clays in the southern portion of the Hackensack River Valley. The timing of the drainage was 17,000 YBP or somewhat earlier (Stanford and Harper 1991). This indicates that glacial lakes Bayonne and Hackensack persisted for approximately 3,000 years. Drainage of glacial Lake Hackensack exposed the lake-bottom deposits.

South of Moonachie, the exposed clays became desiccated and cracked (Stanford and Harper 1991). The desiccated Hackensack Lake bottom deposits are encountered in the subsurface as stiff clays overlying soft clay. They have been encountered as deep as 60 feet below sea level at Newark and 30 feet below sea level at Secaucus. The early post-glacial, pre-rebound lake(s) were only present north of Moonachie, since no desiccated clays have been encountered in the subsurface south of that area (Lovegreen 1974; Stanford and Harper 1991).

Stanford (1993) indicates that borings in the Hackensack and Overpeck valleys reveal alluvial sand-filled channels were incised as much as 20 feet into the former glacial Lake Hackensack plain before sea level rise created tidal conditions in the valleys. Those valleys are now covered by salt-marsh peat.

A series of terrace deposits were laid by the stream-deposition during the pre-rebound interval. These included the Oradell terrace, the Moonachie terrace, and the lower Passaic terrace (Stanford and Harper 1991). The Oradell terrace was deposited by a northward flowing stream draining the lower Hackensack valley. The lower Passaic and Saddle Brook rivers drained eastward across the former lake-bottom of glacial Lake Paramus between Passaic and Hackensack, joining the northward flowing Hackensack River just north of Hackensack. The river continued to the north discharging into Lake Hudson through the Sparkill Gap (Stanford and Harper 1991).

Stream-flow reversed to its present southward direction in the Hackensack River as post-glacial rebound raised the northern portion of the river valley with respect to the southern portion (Stanford and Harper 1991). The southward flowing stream re-worked the Oradell terrace deposits and began to form the Moonachie terrace (Qmt, Figure B-2). Stanford and Harper (1991) cite a radiocarbon date of 12,870 ±200 YBP from Averill et al. (1980) as a minimum age for the stream-flow reversal. The Moonachie terrace deposits lie in relatively close proximity to the north and northeast of the Arsynco site (see Figure B-2).

The upper portions of the delta deposits from the glacial Lake Bayonne stage have been subaerially exposed since the lowering of the Lake Bayonne level to the Lake Hackensack level. Lower levels of those delta deposits have been exposed since the drainage of Lake Hackensack. Thus, the lower levels of the delta deposits, where they were not covered by glacial Lake Hackensack lake-bottom deposits, have been exposed to erosion for approximately 17,000 years.

Sea-level rise eventually brought tidal conditions into the Hackensack River valley. Stanford (1993) cites Heusser (1963) to help constrain the timing. Heusser gave a radiocarbon date of 2,025 ±300 YBP for a basal freshwater peat below the salt marsh sediments near the intersection of NJ Route 3 and the New Jersey Turnpike. Thus, the 10-foot sea level rise that created the present Hackensack salt marsh occurred within the past 2,000 years. A remnant exposure of a freshwater marsh (Qs) borders the southern edge of Teterboro Airport, as shown along the northern edge of Figure B-2.

1.2.4 Site-Specific Geology

The local stratigraphic and hydrostratigraphic interpretation of the site were based on five separate but related lines of evidence. The fundamental basis was the well and boring logs from previous investigations at the site (refer to 1997 RIR and 1999 RAW submittals), as well as logs from the more recently installed monitoring wells (2003 RAW). These logs were interpreted based on a refinement of the geologic units described by Harper (1993) and the framework of the glacial lake history of Stanford and Harper (1991) which were described above. Interpretation between borings was aided by reference to historical Arsynco ground water level maps, particularly the three most recent maps which incorporate the newly installed on-site and/or off-site wells (March 2002, May 2002, and May 2003). The current conceptual understanding of the site tidal response and how it influences the ground water maps was also integrated into the hydrostratigraphic interpretation.

Figures B-6 through B-10 are cross-sections representing the Arsynco site hydrostratigraphy based on the framework of Stanford and Harper (1991) and Stanford (1993). Figure B-11 shows the location of the local geologic cross-sections. The contacts between the deltaic deposit (Q_{bn}) and lake bottom deposits (Q_{bnl}) in these sections are highly schematic interpretations. The purpose is to reflect the character of how the deltaic deposit grades into the lake bottom deposits. The complexity of the site stratigraphy derives from the site's location along the boundary between the glacial Lake Bayonne deltaic deposit (Q_{bn}), the glacial lake bottom deposits (Q_{hkl} and Q_{bnl}) and the salt marsh deposits (Q_m).

The deltaic deposit is expressed at the surface in the low lying trough which trends northeast from Rutherford, through East Rutherford, and into Carlstadt (see Figure B-5b). This deltaic deposit is most likely a Gilbert-type delta deposit (Gilbert 1885; 1890; LeBlanc 1975; Blatt, et al. 1980). Most deltas are deposited from a fan-jet type of mixing model because the river water is generally less dense than the lake or ocean into which it flows. For glacial meltwater streams entering a glacial lake, however, the water will generally be denser than the lake due to its colder temperature and high sediment load (Blatt, et al. 1980). This results in deposition from an axial-jet mixing model which yields a different geometry of deposition.

Gilbert (1885) presented the classic description of deltas, focusing on the delta formed in glacial Lake Bonneville. An important feature of this type of delta is the very steep cross-bedding that occurs as the coarse material is deposited on the delta-front. This cross-bedding dips at close to the angle of repose (Figure B-12), and is generally observed to be in the range of 10° to 25° (Gilbert 1885; LeBlanc 1975). The pattern of sediment deposition in this type of delta is illustrated on Figures B-12 and B-13. Figure B-12 shows the high angle of cross-bedding that forms as the delta progrades out over the lake-bottom silts and clays. The front of the delta, where the cross-beds are deposited, is steep because the cold, sediment-laden melt-water from the receding glacier is as dense as or more so than the glacial lake water. An axial jet mixing model results and the coarser sediment is quickly deposited down the front of the prograding delta (Blatt, et al., 1980).

Deposition of glacial lake deltas occurs in an interleaving lobate pattern as the delta progrades out over the glacial lake bottom clays and silts (Gilbert 1885; Ashley 1975). The schematic three-dimensional pattern of deposition is illustrated in Figure B-14. The toe of the delta flattens out, and the material becomes finer, grading into fine sand and silt (see Figure B-12). The "silt, trace fine sand" noted for several intervals in the boring log from well MW-25D and similar descriptions from other wells (e.g., MW-5D, MW-9D, MW-10D, MW-12D, MW-13D) were interpreted to be representative of the delta-toe. The toe of the delta grades into the varved lake bottom deposits. These varves consist of alternating layers of very fine sand and silt with thin, draped layers of clay deposited during winter months when glacial melting and sediment influx to the lake decreased (Ashley 1975; Gustavson 1975; Shaw 1975). The pattern of the cross-section between wells MW-11D and MW-25D in Figure B-6 is consistent with the interpretation of Stanford (1993). The silt at the bottom of the MW-11DD boring is interpreted to be representative of thicker varve deposits formed by interflows emerging from the melting and retreating glacier during the Lake Bayonne water level stage. These interflows emerge from submerged melt-water tunnels in the ice-face (Gustavson 1975), and their sediment load is deposited from density currents that spread out over the lake bottom (Figure B-15).

Progradation of the delta to the east into glacial Lake Bayonne is illustrated most clearly in Figure B-7 (cross-section BB'). The thickness of the delta deposit is greatest along the western boundary of the site, and it thins to the east. The sediments also become finer to the east. It is likely that the delta grades into the lake bottom deposits before reaching the eastern boundary of the Arsynco property. This is consistent with Stanford's (1993) interpretation illustrated in his NNE-SSW cross-section (reproduced in part as Figure B-4, herein) which shows no delta deposits. The lowest unit illustrated in Figure B-7 is interpreted to be representative of the glacial Lake Bayonne lacustrine fan deposits (Q_{bnf}) of Stanford (1993). This is also consistent with Stanford's (1993) cross-section illustrated in Figure B-4.

Figure B-16 provides a schematic view of the glacial Lake Bayonne delta near the Arsynco site. The Arsynco site is located at the northeastern edge of the delta (i.e., near the delta front), which leads to the stratigraphic complexity. Only one generalized lobe is illustrated for the delta in that schematic view. However, the distribution of the deltaic sediments near East Rutherford and Carlstadt on Stanford's (1993) map (see Figure B-2) suggest at least three major lobes occurred during deposition of the delta. Further, the more detailed well data from the Arsynco site appear to support further sublobes formed in that area of glacial Lake Bayonne.

A potential example of an additional sublobe is illustrated in cross-sections BB' and CC' (Figures B-7 and B-8) between wells MW-6D, where the top of the delta may be encountered at a higher elevation than in well MW-17D. An alternative interpretation is that a gully was eroded into the front of the delta deposits during the subaerial exposure prior to introduction of the tidal influences and resultant deposition of the salt marsh (Q_m).

The lower portion of cross-section DD' (Figure B-9) is a highly schematic interpretation, where an example of the merging of the deltaic deposit into the lake bottom deposits is represented. The historic pattern of ground water flow observed in the deep groundwater zone (D-well zone) was an important constraint used to guide this interpretation. The flow of groundwater in the area of wells MW-9D and MW-13D suggests the region of those wells consists of more permeable sediments, while groundwater in the area of MW-10D appears to flow at a slightly slower rate. The more permeable areas could be due either to the presence of a sublobe of the delta (Q_{bn}) or it could be the result of deposition of alluvial sands into a gully eroded into the lake bottom sediments (Q_{al}). The schematic interpretation provided in Figure B-9 is meant to illustrate this by showing a larger amount of D-well ground water zone (the yellow zone in cross-sections) than the D-DD zone confining unit sediments in the area of wells MW-9D and MW-10D relative to the other wells shown further south. In addition, the tendency for the deep (D-well) zone ground water to flow toward the south-southeast or southeast in the region of well MW-13D is represented in similar fashion.

GEOLOGIC CSM (2013 UPDATE)

2.0 GEOLOGY

The conceptual model for the geology and hydrogeology of the Arsynco Site was developed in detail and presented in the December 2003 RIR Addendum and RAW (JMC, 2003). The model was based on a thorough literature review, Site geologic data from borehole logs, and Site hydrogeologic data. Subsequent investigations have been consistent with that conceptual model. The conceptual geologic model for the Site is also fully supported by the information in NJDEP's i-MapNJ Geology, which identifies the "Surficial Aquifer" data layer for the west part of the Site as "Sand and Gravel" and the Site area to the east of that as "Lake-bottom Sediments." The transition line between these different deposits that is shown on i-MapNJ follows a very similar line as developed by JMC and illustrated on Figures B-2 and B-22. This section provides a brief overview of the Site geologic model developed in JMC (2003) along with supplementary material to aid understanding of that model.

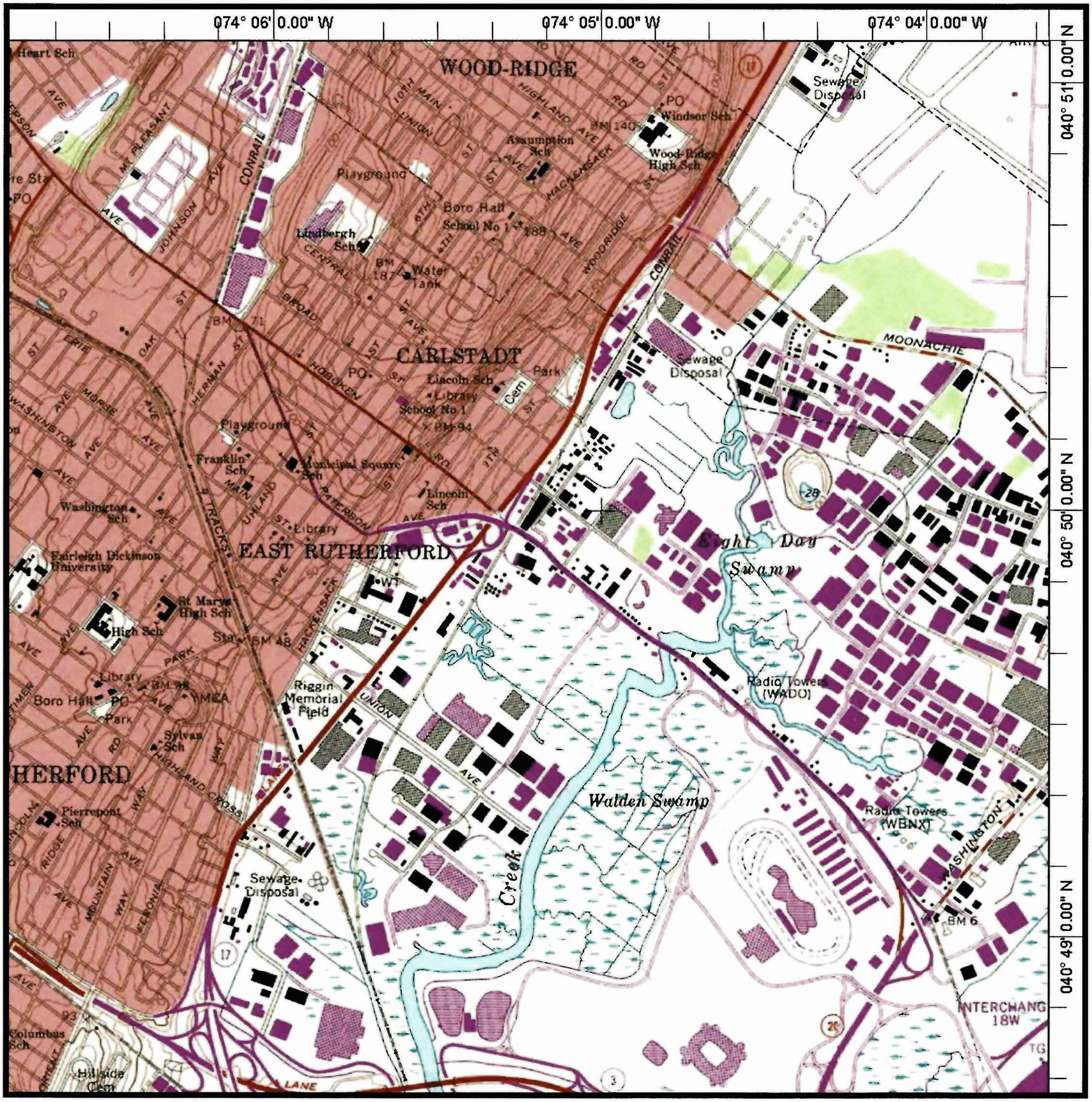
The primary geologic formations of interest underlying the Site are, in order from depth moving toward the surface: glaciolacustrine sands, silts, and clays, salt marsh silts, clays and peat, and, at the surface, artificial fill. The geologic history of these sediments was presented in detail in JMC (2003). The geologic units and stratigraphy are based on Stanford (1993). Figure B-2 is a regional geologic map illustrating the surface distribution of these sediments in the vicinity of the Site and the location of the Site within the geologic setting. Figure B-3 is a regional geologic cross-section illustrating the distribution of geologic formations in the subsurface along a NW-SE transect approximately 1.9 miles south-southeast of the Arsynco Site. Figure B-4 is a cross-section of the subsurface distribution of Quaternary sediments along a NE-SW transect passing approximately 140 feet east of the Arsynco Site.

The Arsynco Site straddles a delta complex that was deposited into Glacial Lake Bayonne (Q_{bn}). This is illustrated in the idealized cross-section of Figure B-12. The delta complex consists of a wedge of sands, silts, and clays that grade into the varved silts and clays of the lake bottom sediments of Glacial Lake Bayonne (Q_{bnl}). A later glacial lake stage, Glacial Lake Hackensack, deposited lake bottom sediments above these formations (Q_{hkl}). An extended period of subaerial exposure and erosion followed the drainage of the glacial lakes as glacial rebound uplifted the area. As sea level rose with the continued melting of the glaciers, a Quaternary salt marsh deposit was deposited over the top of the glacial lake sediments. In the late 19th century and early 20th century, humans began to fill the marsh deposits to make usable land. These artificial fill sediments comprise the uppermost geologic layer at the Site.

Important features of delta complex sediments are illustrated in Figures B-17 through B-21. Figure B-17 presents a schematic illustration of delta complex geometry and sub-environments of deposition along with sedimentary structural characteristics expected in those settings. Figure B-18 shows a cross-section of a glacial delta complex located in Connecticut that can serve as an analog for understanding the Arsynco Site. The very coarse-grained nature of the topset beds and the steeply dipping foreset beds can be observed toward the top and middle, respectively, along the right side and middle of the photograph that comprises Figure B-18. These sediments are interpreted to be representative of Arsynco Site sediments along the western margin and southwestern portions of the Site. They are also characteristic of the sediments underlying the western section of the Cosan Chemical site to the south of the Arsynco Site and are present below AOC MW-2 at the Cosan site, which is the location of a DNAPL source that impacts the southern portion of the Site. Foreset beds in glacial lake deltas dip at angles of between 20° and 25° (Dr. Julie Brigham-Grette, personal communication). Bottomset beds that merge into the glacial lake bottom varved silts and clays can be observed at the left of the photograph in Figure B-18. The transition from the coarser, more permeable foreset beds into the finer bottomset beds and varved silts and clays can occur over rather short distances. This transition occurs over distances of between 20 and 60 feet depending on the delta thickness and the angle of the foreset beds. Figure B-19 is a photograph illustrating the steepness of foreset beds in a similar glacial lake delta.

Figures B-20 and B-21 illustrate the laminated and disrupted-lamination structures (due to dewatering) of bottomset beds. These very fine sand to silt and clay sediments, characteristic of the delta toe, are expected to present a significant barrier or retarding influence on the migration of contaminants. The deep groundwater zone throughout most of the northeastern portion of the Arsynco Site is interpreted to be comprised of sediments deposited in the delta toe and/or the glacial lake bottom. These sediments have quite low hydraulic conductivity. Hydraulic conductivity values range from 0.01 to 0.5 ft/day in Arsynco wells and in Cosan wells set in this type of depositional setting.

The transition zone between the coarser topset and foreset deltaic sediments and the bottomset deltaic sediments and their merger with the varved glacial lake bottom sediments plays an important role in understanding the Site hydrogeology and contaminant behavior. Figure B-22 is a map of the estimated location for this transition zone at the Arsynco Site and northern portion of the Cosan site. The location was determined primarily by its influence on hydrogeologic properties and response. The transition zone was assumed to be 50 feet wide. Its location between wells MW-15D and MW-29D is based on the steep hydraulic gradients that have been historically observed between these wells. The transition zone was assumed to incorporate hydraulic conductivity (K) values in the range of 0.5 to 2.0 ft/day. K-values greater than this are presumed to lie in the delta forebed and topset bed region to the west and southwest of the Site. K-values below this range are presumed to lie in the bottomset beds of the delta toe where they merge with the varved silts and clays of the glacial lake bottom.



Scale 1:24,000

Source: USGS Topo Quad. - Weehawken Quad, Photorevised 1981

Site Coordinates: Latitiude: 040° 50' 8.32" N
Longitude: 074° 05' 0.58" W

SITE LOCATION MAP

Arsynco, Inc. Property
511 13th Street
Carlstadt, New Jersey

FIGURE B-1

JMC Environmental Consultants, Inc.

2109 Bridge Ave., Bldg. B
Point Pleasant, New Jersey 08742

Legend

Lithology

a_f Artificial Fill

Postglacial Deposits

Q_m Estuarine and salt-marsh deposits

Glacial Lake Hackensack Deposits

Q_{hkl} Lake-bottom deposits

Glacial Lake Bayonne Deposits

Q_{bn} Deltaic deposits

Q_{bnl} Lake-bottom deposits

Q_{bnf} Lacustrine-fan deposits

Glacial Deposits

Q_t Rahway Till

Other Symbols

River or stream

109 (-230) Well or boring location with depth in parenthesis

Arsynco property with selected well locations

B B' Location of geologic cross-sections from Stanford (1993)

Scale

0 2000 4000

Scale (feet)

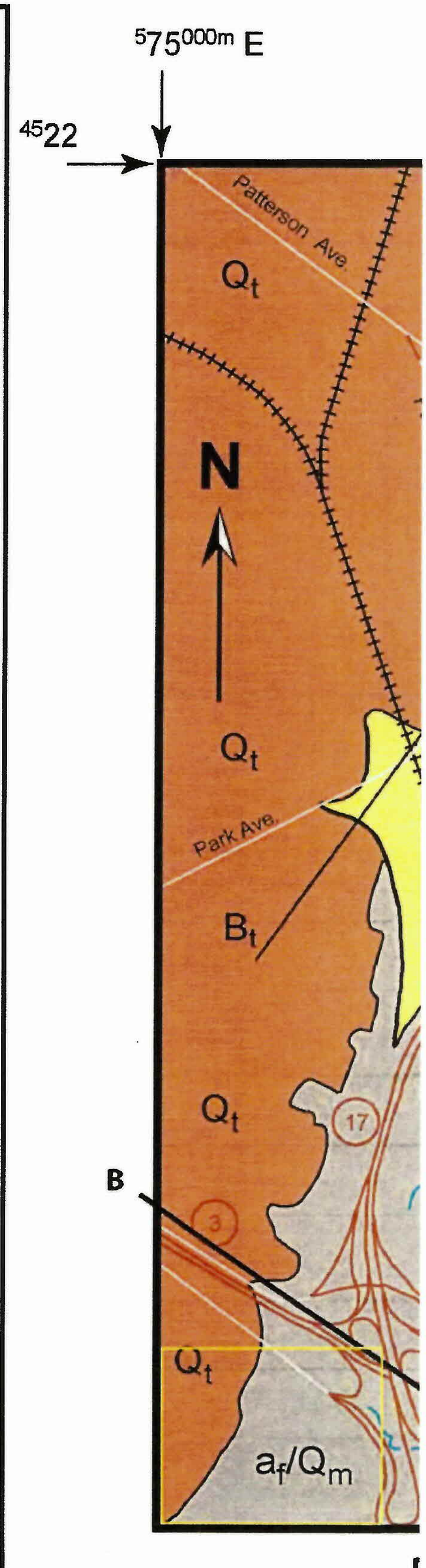
Geology Sources

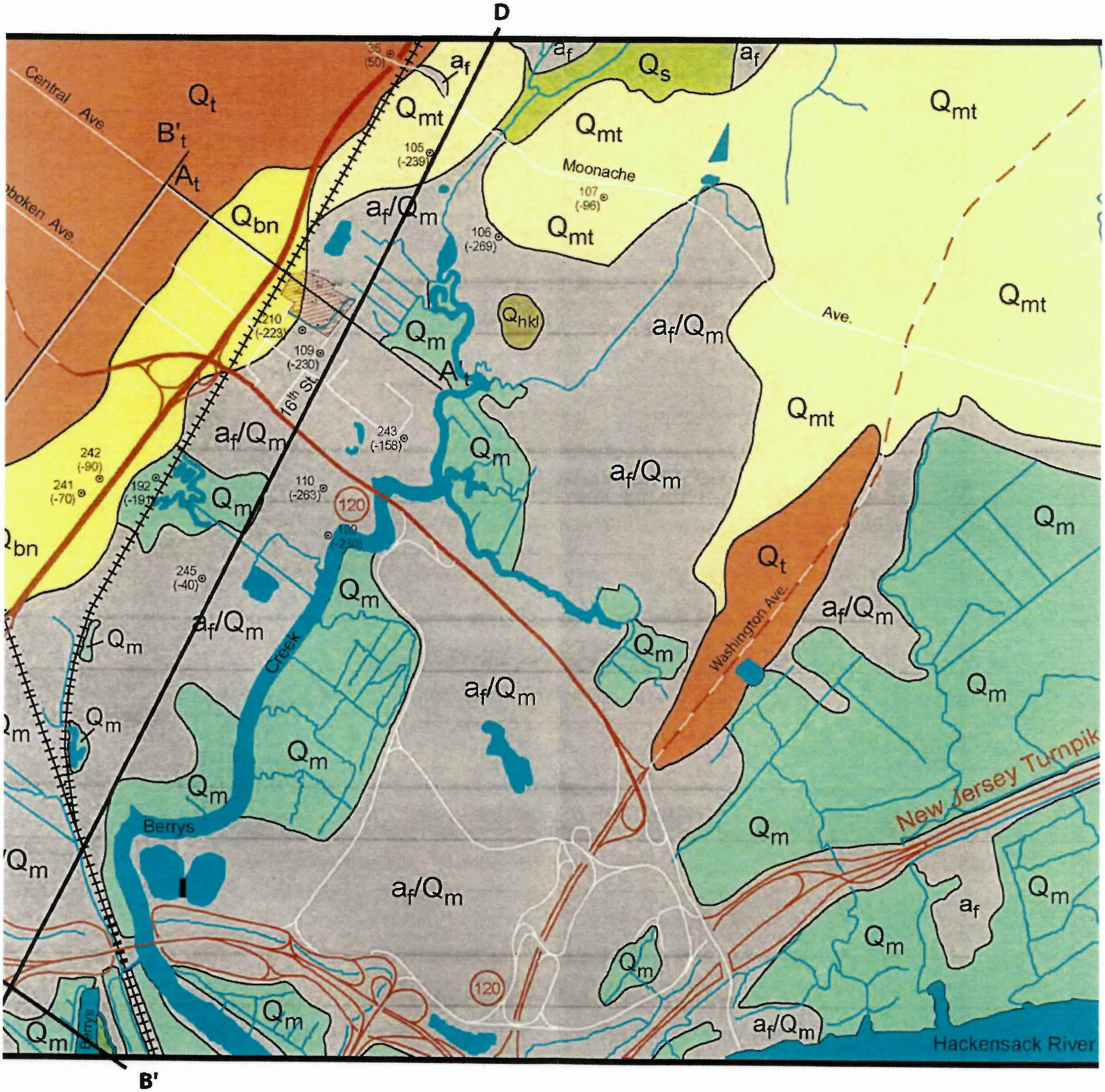
Quaternary units from Stanford (1993)

Bedrock units from Avery et al. (1996)

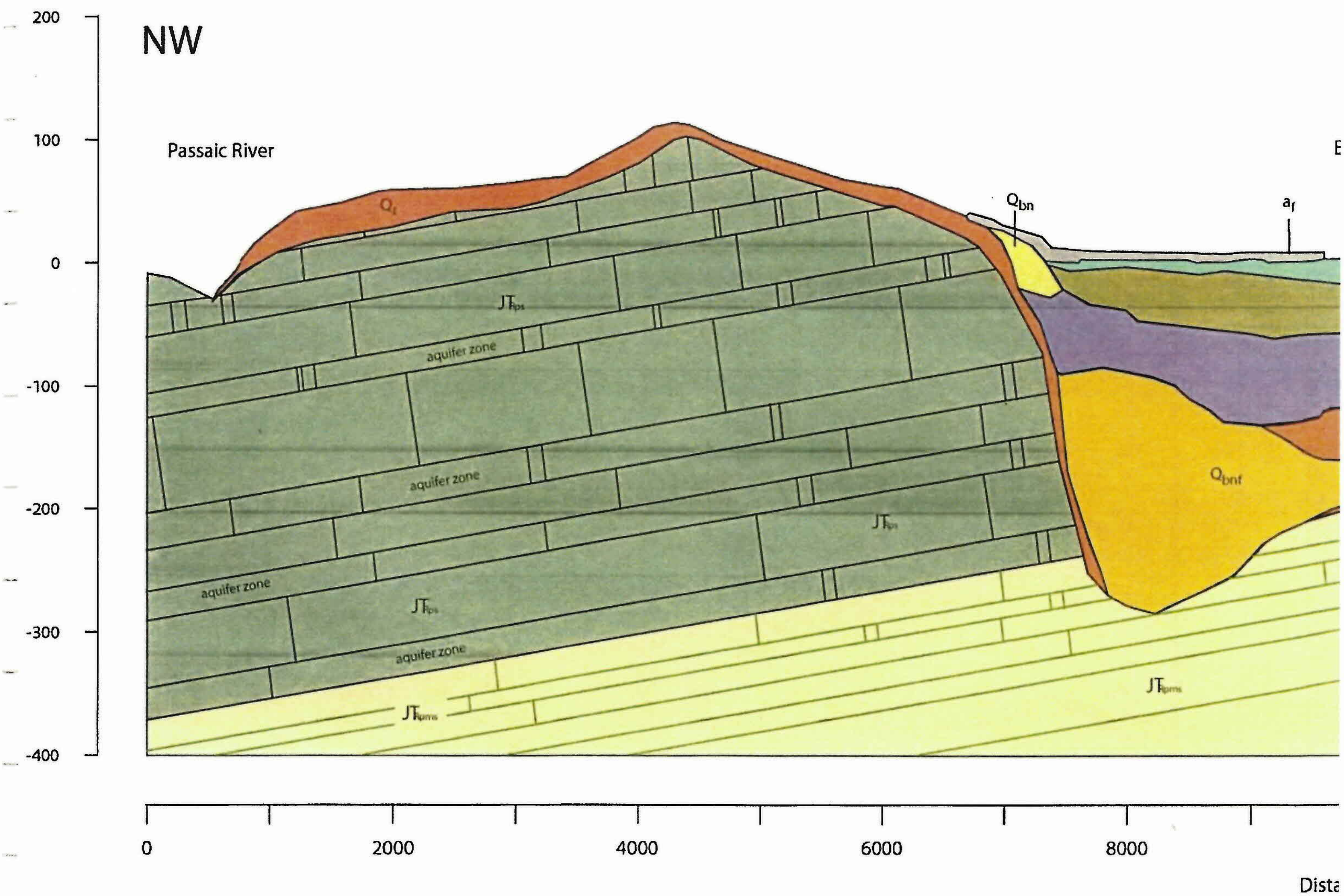
Figure: B-2

Surface Geologic Map
Arsynco Site
Carlstadt, NJ





D
Q_t
Central Ave.
B'_t
A_t
oboken Ave.
Q_{bn}
a_f
Q_{mt}
Q_s
a_f
Q_{mt}
Moonache
Ave.
Q_{mt}
Q_{mt}
Q_{mt}
Q_{mt}
a_f/Q_m
Q_{hkl}
Q_m
A'_t
16th St.
a_f/Q_m
a_f/Q_m
a_f/Q_m
Q_m
Q_m
Q_m
Q_t
Washington Ave.
a_f/Q_m
Q_m
Q_m
Q_m
Creek
Q_m
Q_m
Q_m
Berrys
a_f/Q_m
Q_m
Q_m
New Jersey Turnpik
Q_m
a_f
Q_m
Q_m
120
120
Q_m
Q_m
Berrys
a_f/Q_m
Hackensack River
Q_{bn}
$/Q_m$
B'
35 (50)
105 (-239)
107 (-96)
106 (-269)
210 (-223)
109 (-230)
243 (-158)
242 (-90)
241 (-70)
192 (-191)
110 (-263)
109 (-230)
245 (-40)



Lithology

a_f Artificial Fill

Postglacial Deposits

Q_m Estuarine and salt-marsh deposits

Glacial Lake Hackensack Deposits

Q_{hkl} Lake-bottom deposits

Glacial Lake Bayonne Deposits

Q_{bn} Deltaic deposits

Q_{bnl} Lake-bottom deposits

Q_{bnf} Lacustrine-fan deposits

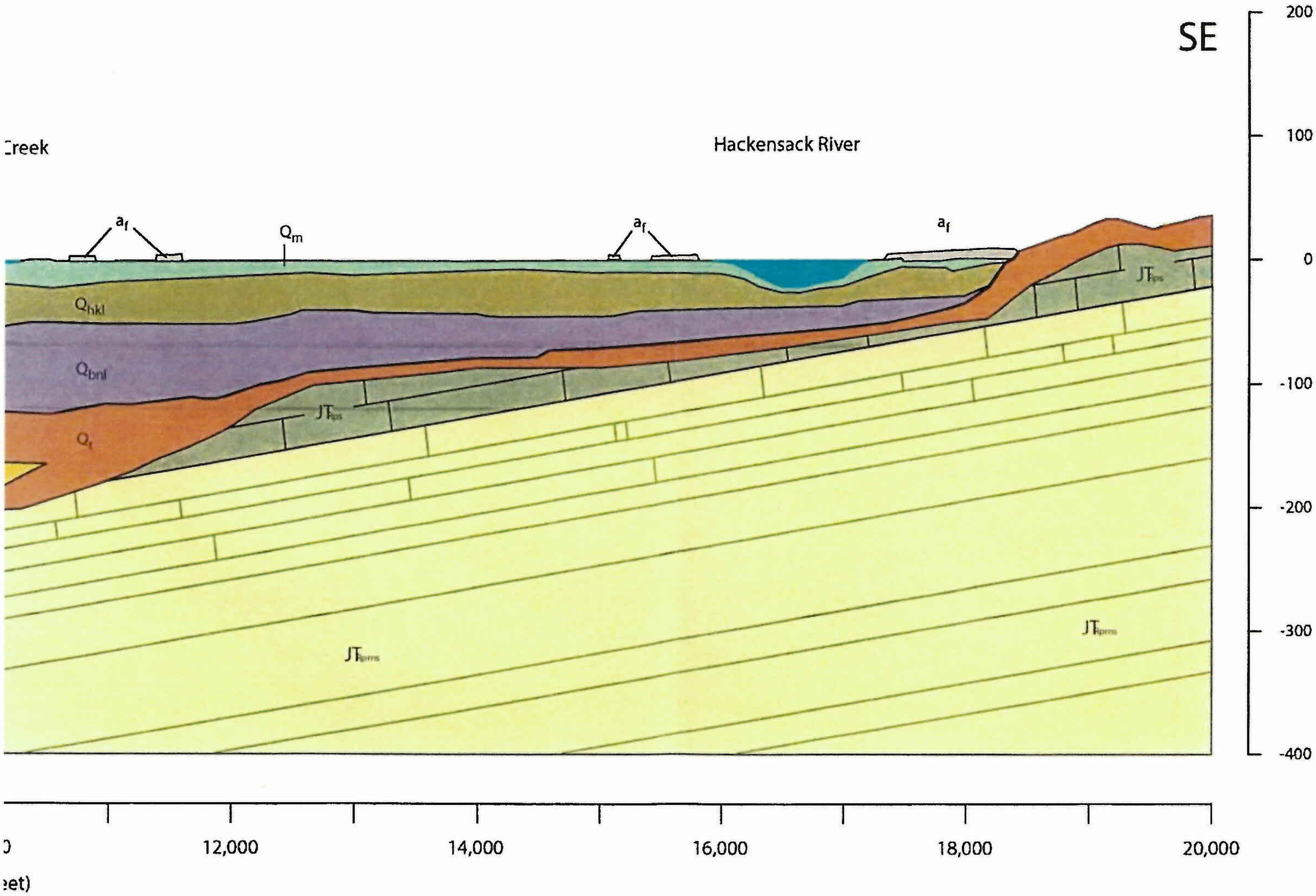
Glacial Deposits

Q_t Rahway Till

Passaic Form

JTr_{ps} sandstone

JTr_{pms} sandy mud



:nd

Lower Jurassic and Upper Triassic)

Other Symbols

Fractured or jointed bed of JTrps

Fractured or jointed bed of JTrpms

Ground water flow path

Overland flow/runoff

River or stream

Geology Sources

Quaternary units from Stanford (1993)

Bedrock units from Avery et al. (1996)

Vertical Exageration = x10

Figure: B-3

ARSYNCO SITE
CARLSTADT, NJ

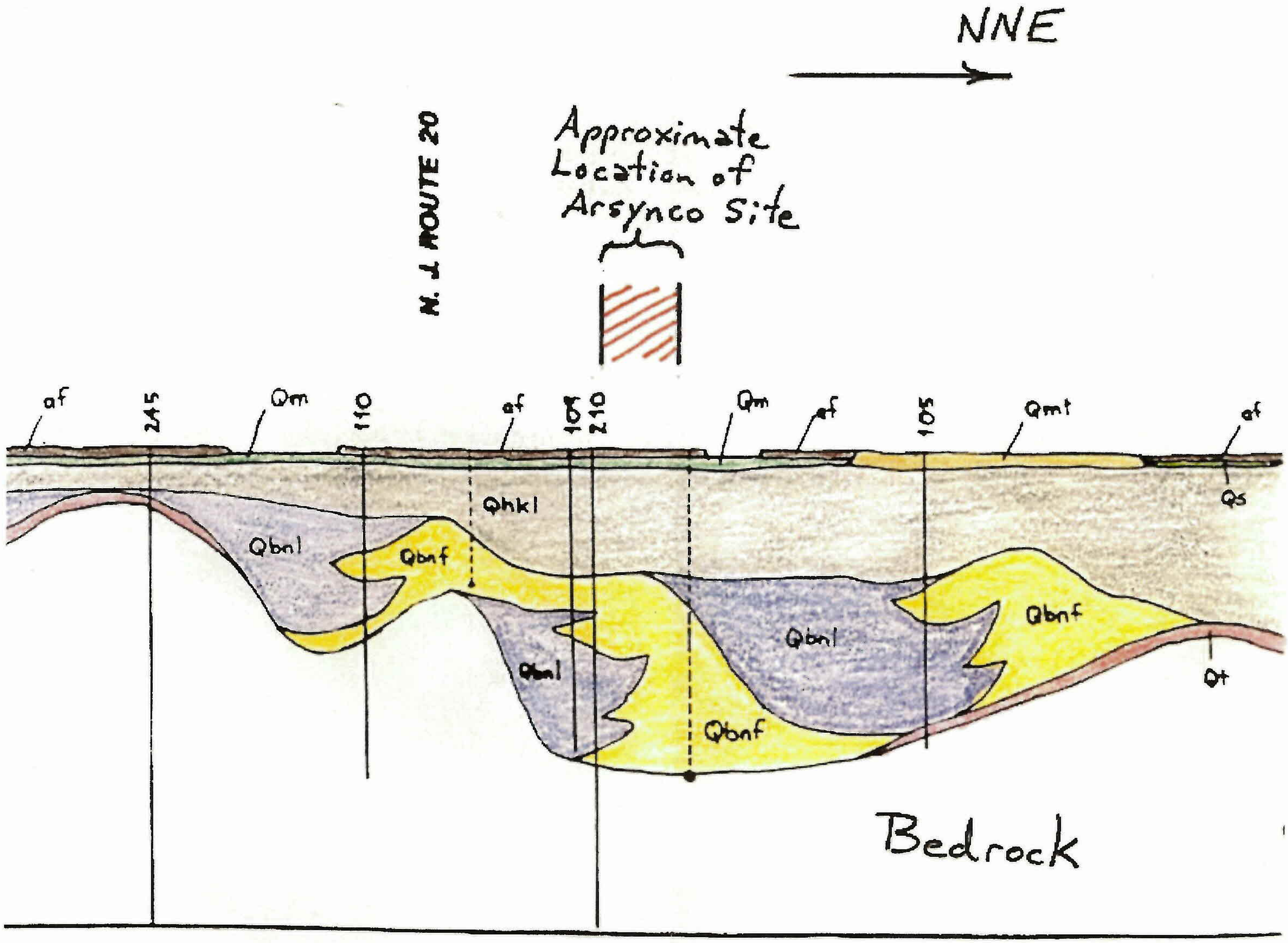
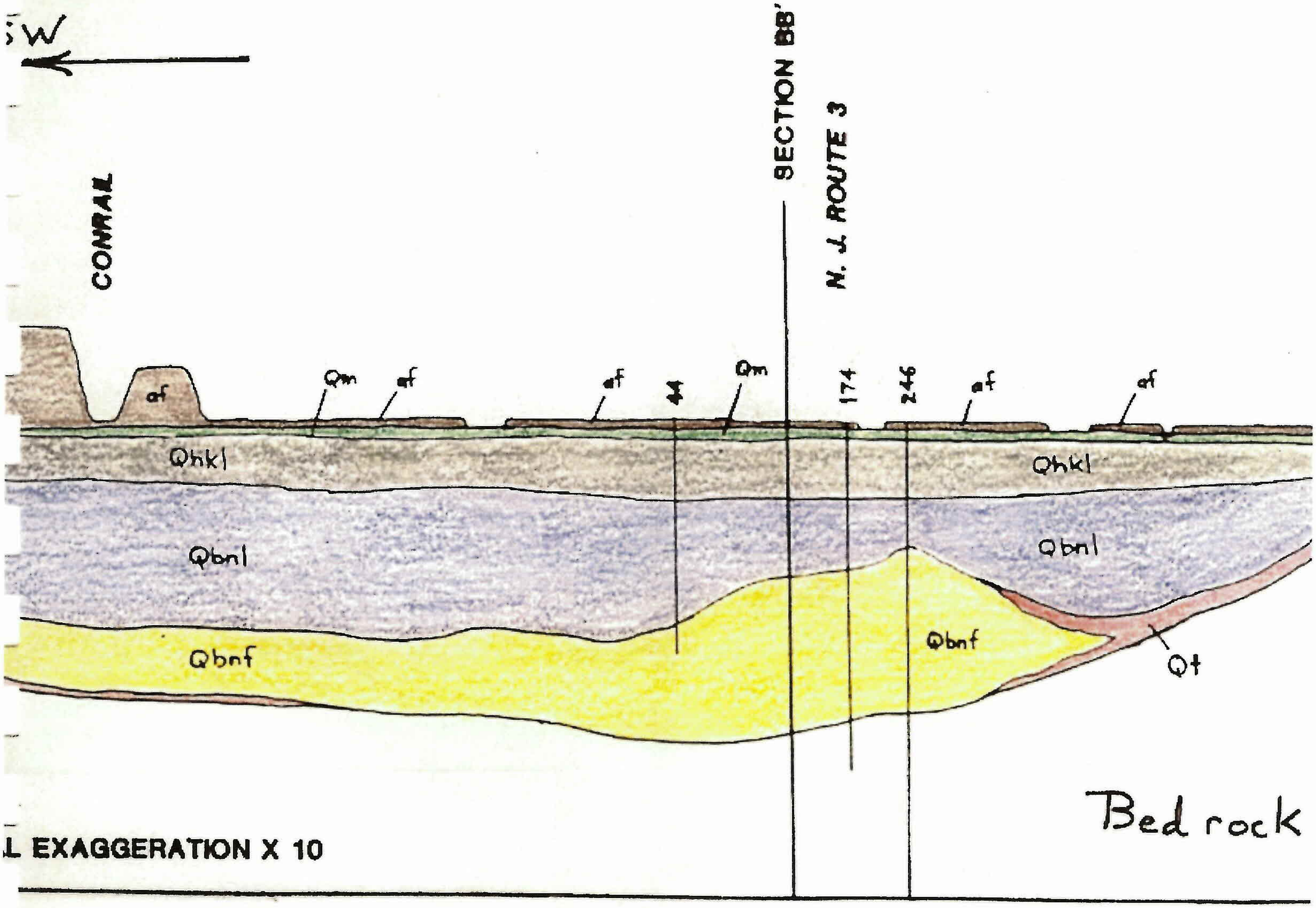


Figure: B-4

ARSYNCO SITE
CARLSTADT, NJ



SW
CONRAIL
SECTION BB'
N. J. ROUTE 3
af
Qm
af
af
44
Qm
174
246
af
af
Qhkl
Qhkl
Qbnl
Qbnl
Qbnf
Qbnf
Qt
Bed rock
L EXAGGERATION X 10

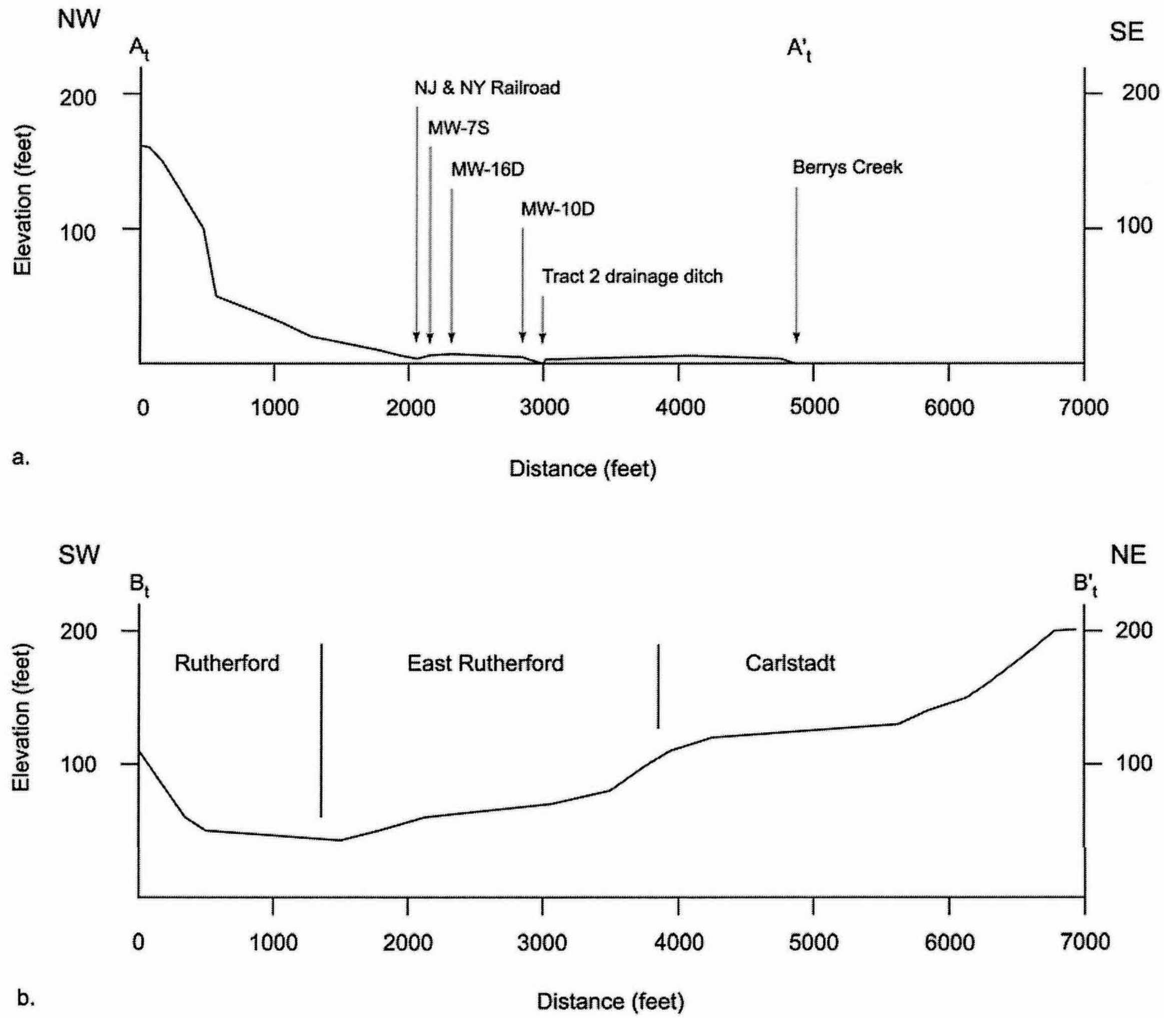
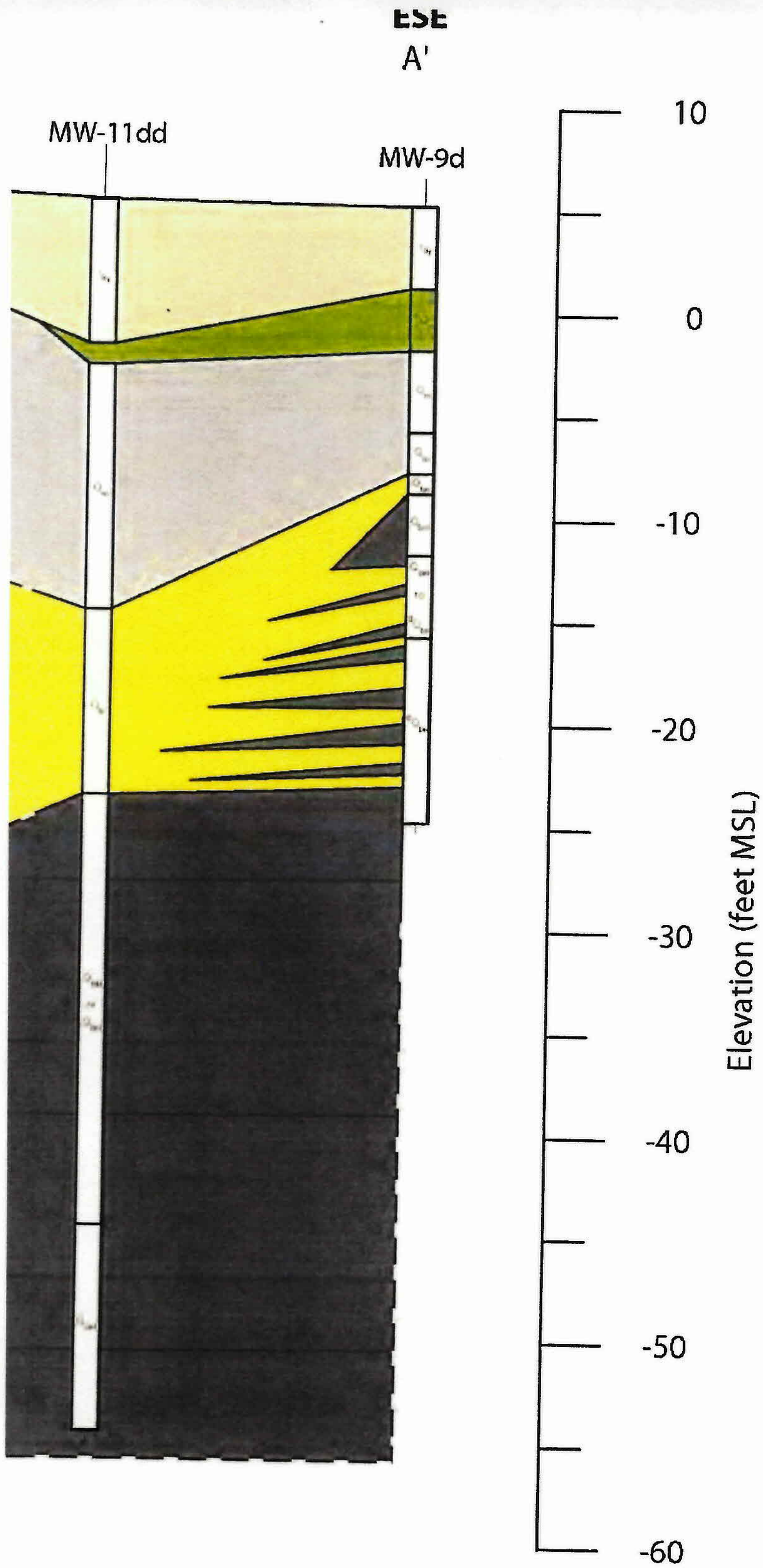


Figure B-5. Topographic cross-sections near the Arsynco, Inc. site. See Figure B-2 for cross-section locations.



LEGEND

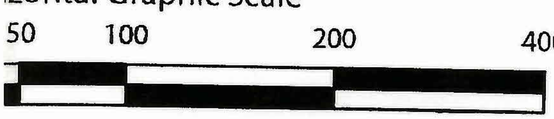
Hydrostratigraphic Classification

- Shallow (s-well) ground water zone
- Meadow Mat
- s-d confining zone
- Deep (d-well) ground water zone
- d-dd confining zone
- Deepest (dd-well) ground water zone

Lithologic Classification

- artificial fill - finer-grained material
- artificial fill - coaser-grained material
- Meadow Mat
- Salt Marsh Deposits
- Alluvial sands
- Glacial Lake Hackensack Bottom Deposits
- Glacial Lake Bayonne Delta Deposits
- Glacial Lake Bayonne Distal Delta Deposits
- Glacial Lake Bayonne Bottom Deposits
- Glacial Lake Bayonne Lacustrine Fan Deposits
- Lithologic Contact
- Inferred Lithologic Contact

izontal Graphic Scale

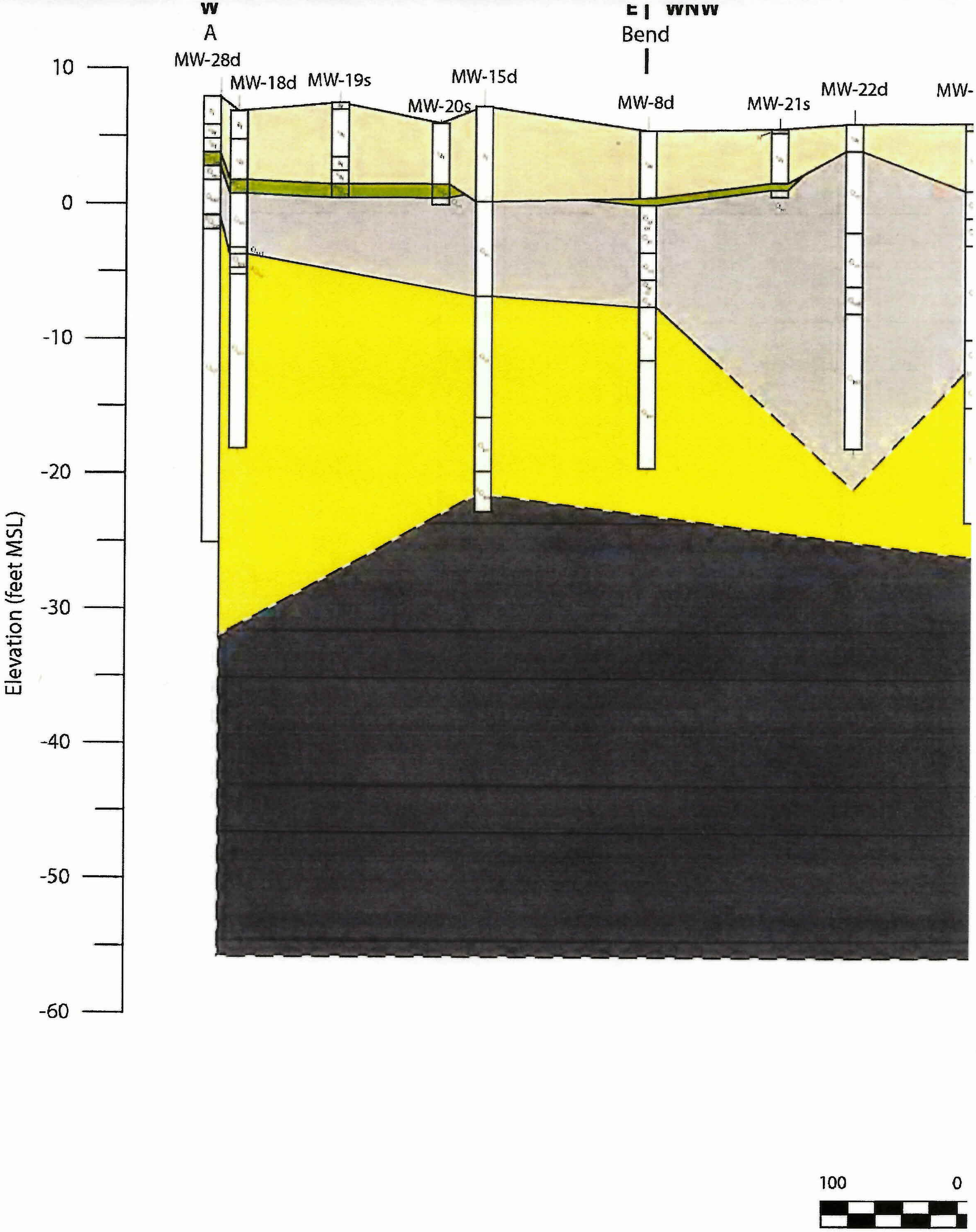


(in feet)
1 inch = 100 feet
tical exageration = x10

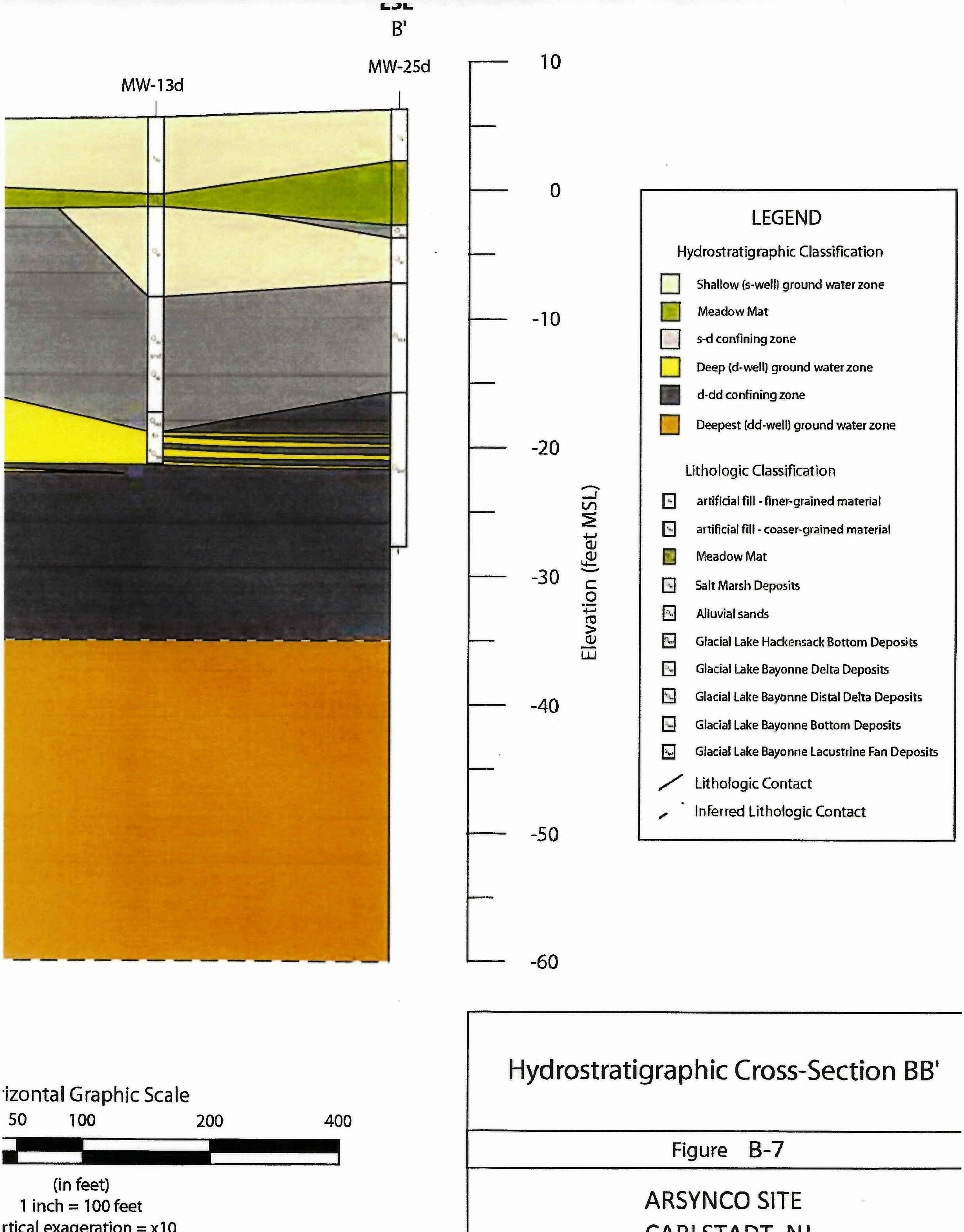
Hydrostratigraphic Cross-Section AA'

Figure B-6

ARSYNCO SITE
CARLSTADT, NJ



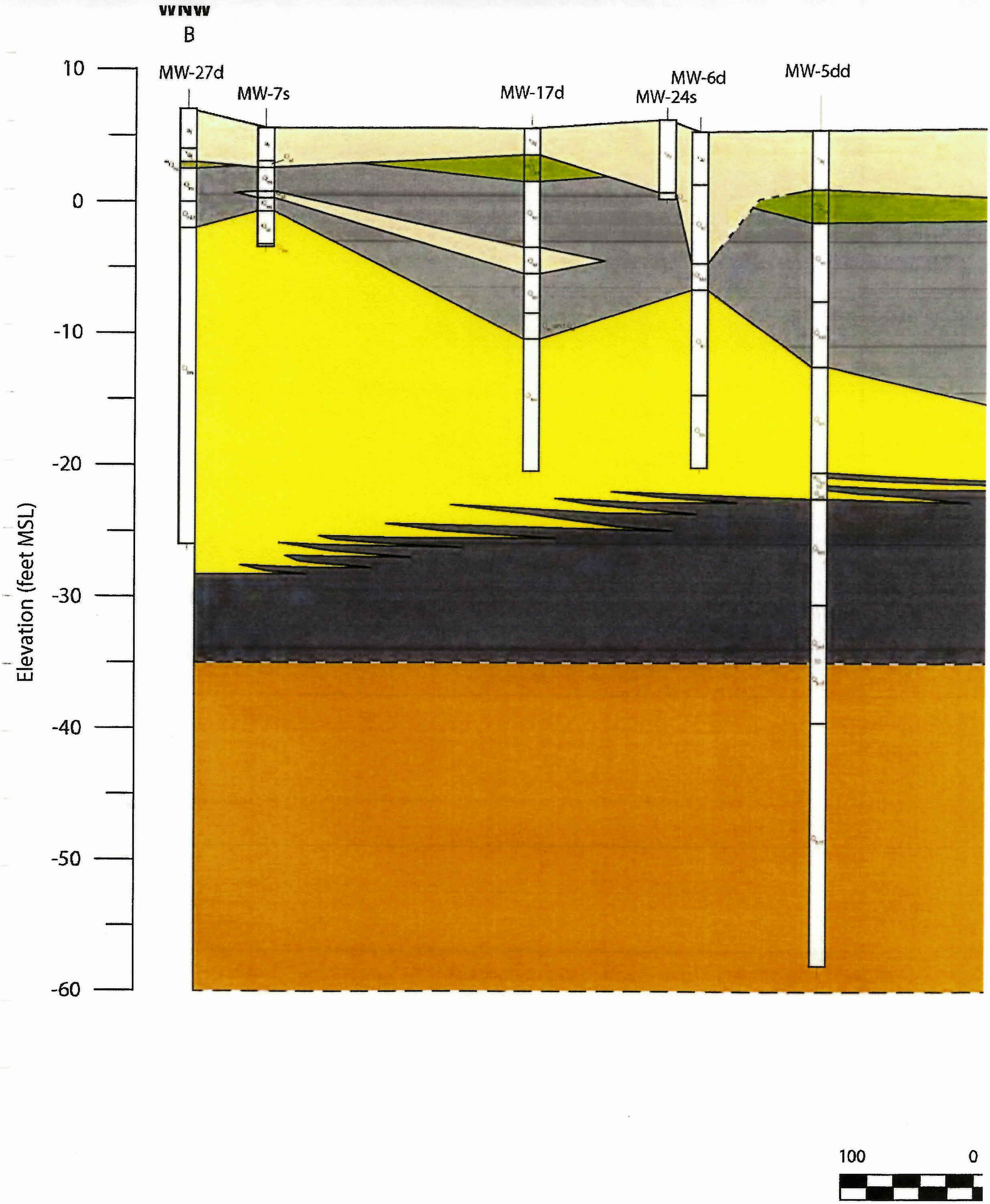
W
A
E
WNW
Bend
MW-28d
MW-18d
MW-19s
MW-20s
MW-15d
MW-8d
MW-21s
MW-22d
MW-
10
0
-10
-20
-30
-40
-50
-60
Elevation (feet MSL)
100
0



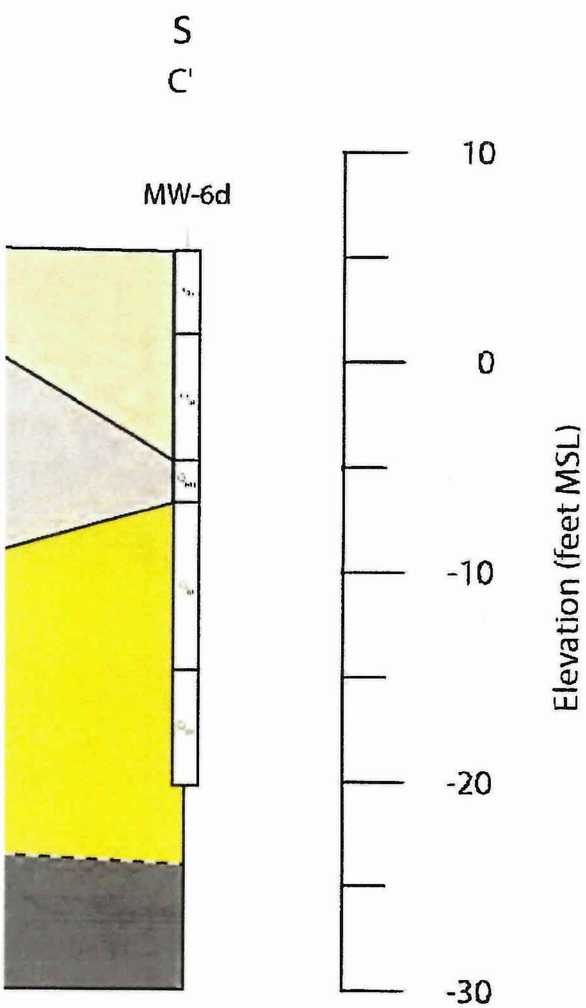
Hydrostratigraphic Cross-Section BB'

Figure B-7

ARSYNCO SITE
CARLSTADT, NJ



WNW
B
MW-27d
MW-7s
MW-17d
MW-6d
MW-24s
MW-5dd
Elevation (feet MSL)
10
0
-10
-20
-30
-40
-50
-60
100
0



LEGEND

Hydrostratigraphic Classification

- Shallow (s-well) ground water zone
- Meadow Mat
- s-d confining zone
- Deep (d-well) ground water zone
- d-dd confining zone
- Deepest (dd-well) ground water zone

Lithologic Classification

- artificial fill - finer-grained material
- artificial fill - coaser-grained material
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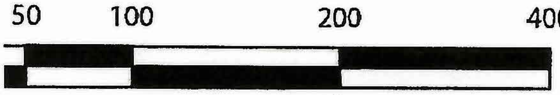
- Salt Marsh Deposits
- Alluvial sands
- Glacial Lake Hackensack Bottom Deposits
- Glacial Lake Bayonne Delta Deposits
- Glacial Lake Bayonne Distal Delta Deposits
- Glacial Lake Bayonne Bottom Deposits
- Glacial Lake Bayonne Lacustrine Fan Deposits
- Lithologic Contact
- Inferred Lithologic Contact

izontal Graphic Scale

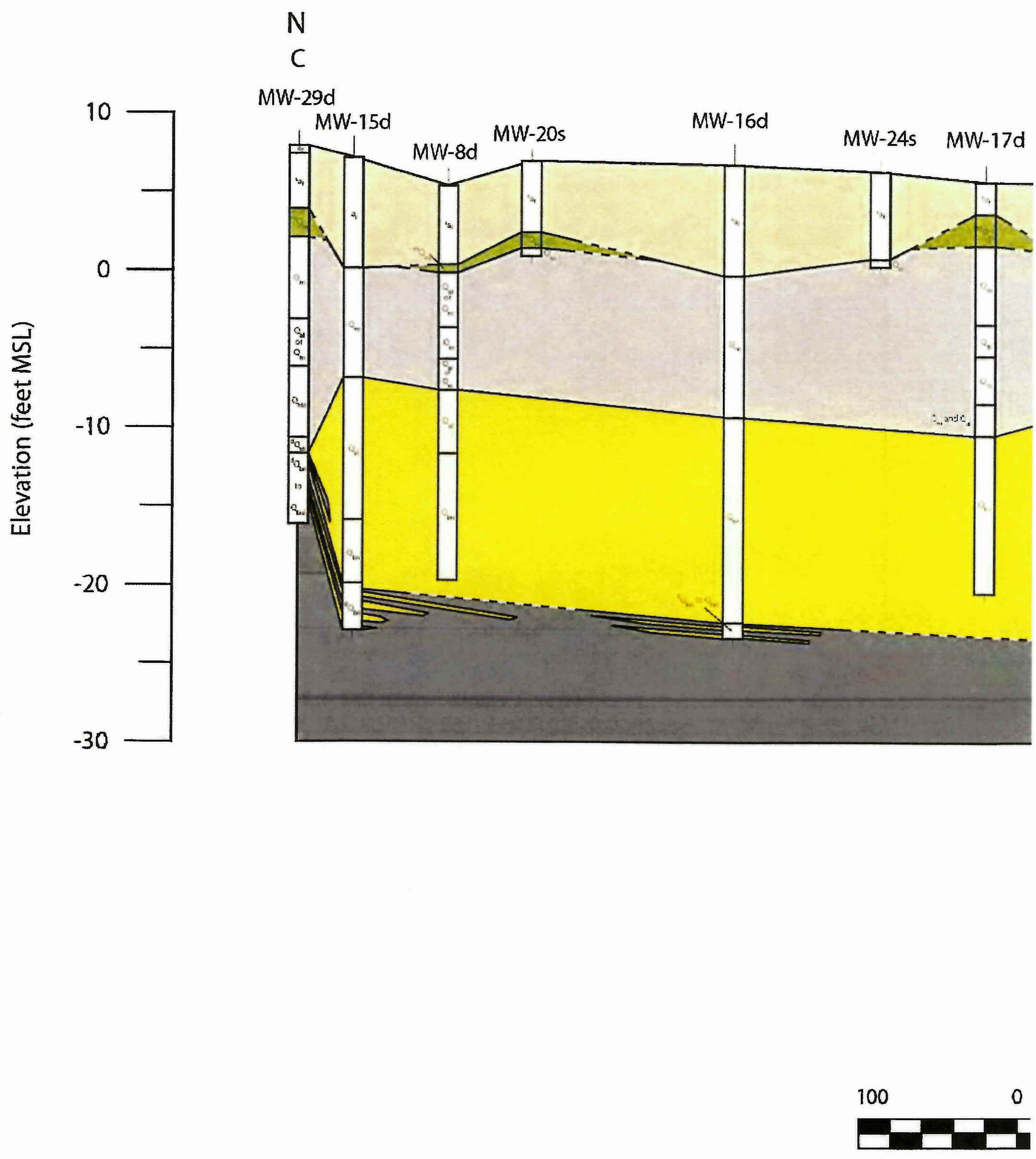


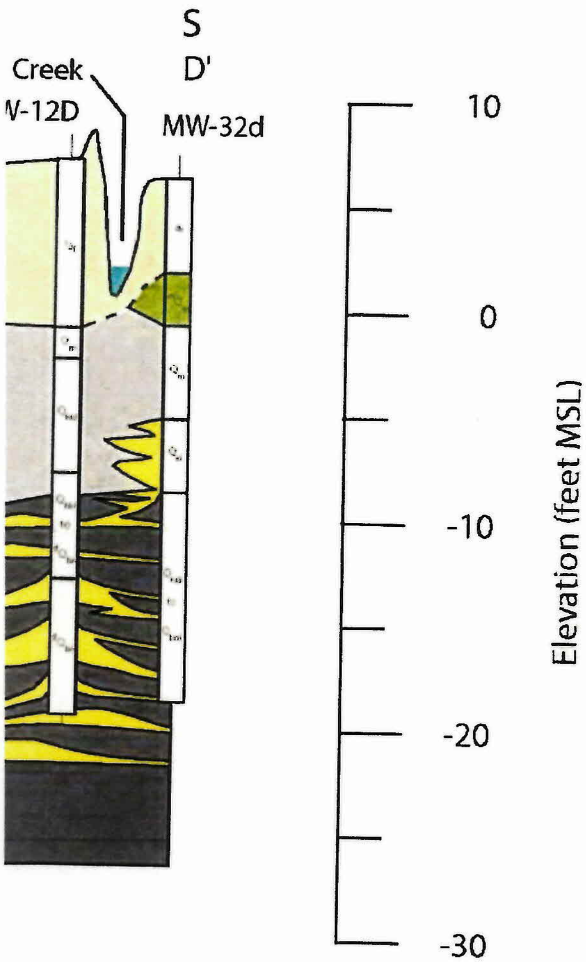
(in feet)
1 inch = 100 feet
rtical exageration = x10

Hydrostratigraphic Cross-Section CC

Figure B-8

ARSYNCO SITE
CARLSTADT, NJ


N
C
MW-29d
MW-15d
MW-8d
MW-20s
MW-16d
MW-24s
MW-17d
10
0
-10
-20
-30
Elevation (feet MSL)
100
0



LEGEND

Hydrostratigraphic Classification

- Shallow (s-well) ground water zone
- Meadow Mat
- s-d confining zone
- Deep (d-well) ground water zone
- d-dd confining zone
- Deepest (dd-well) ground water zone

Lithologic Classification

- artificial fill - finer-grained material
- artificial fill - coaser-grained material
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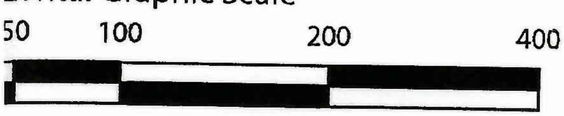
- Alluvial sands
- Glacial Lake Hackensack Bottom Deposits
- Glacial Lake Bayonne Delta Deposits
- Glacial Lake Bayonne Distal Delta Deposits
- Glacial Lake Bayonne Bottom Deposits
- Glacial Lake Bayonne Lacustrine Fan Deposits
- Lithologic Contact
- Inferred Lithologic Contact

zontal Graphic Scale

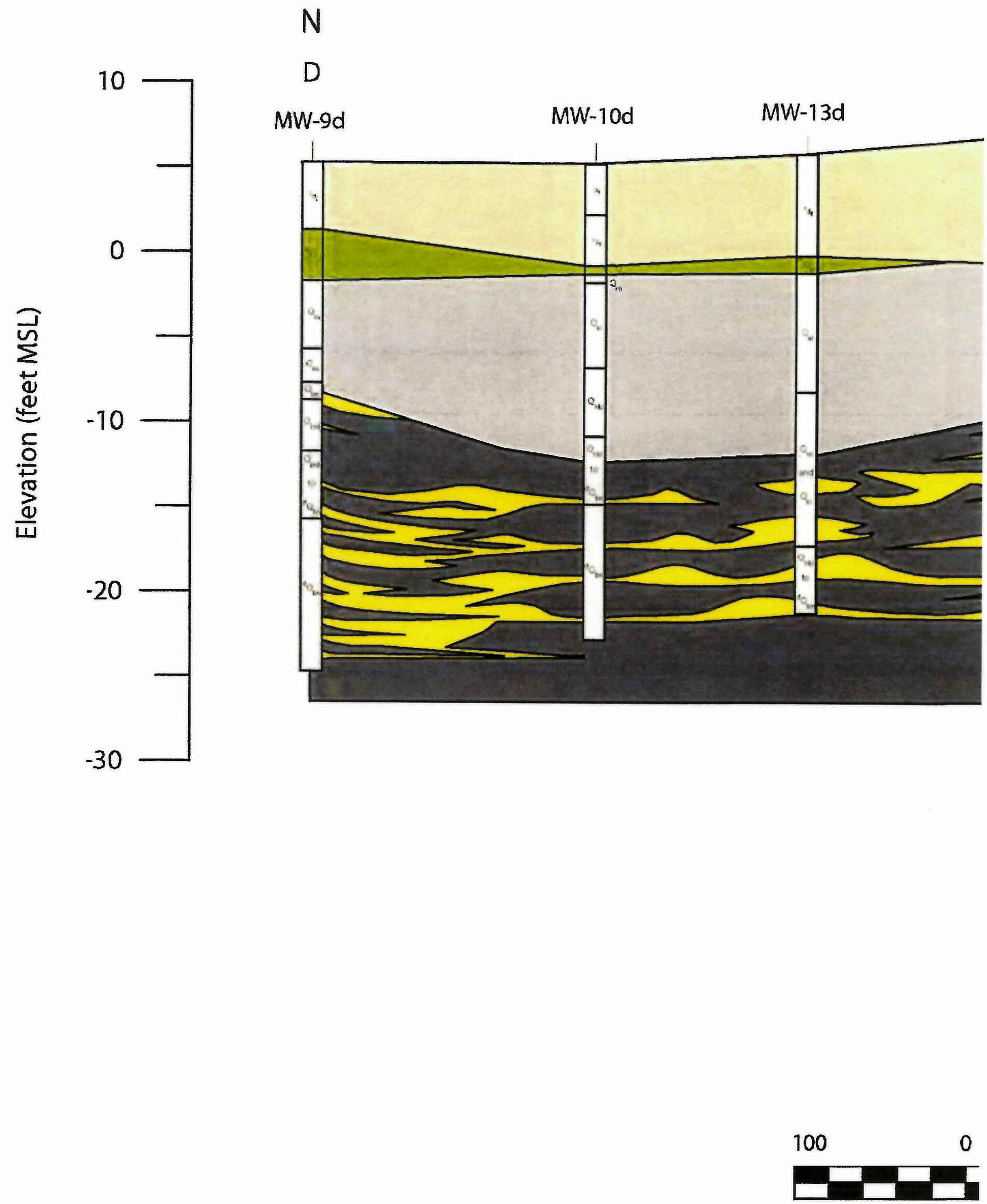


(in feet)
1 inch = 100 feet
:ical exageration = x10

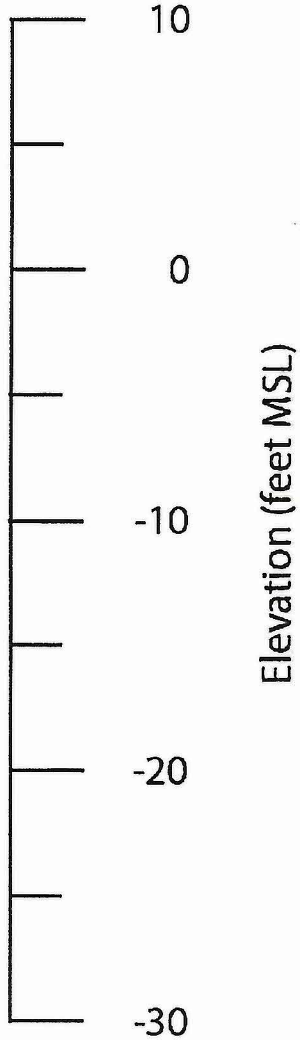
Hydrostratigraphic Cross-Section DD

Figure B-9

ARSYNCO SITE
CARLSTADT, NJ



N
D
MW-9d
MW-10d
MW-13d
10
0
-10
-20
-30
Elevation (feet MSL)
100
0



LEGEND

Hydrostratigraphic Classification

- Shallow (s-well) ground water zone
- Meadow Mat
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- Deep (d-well) ground water zone
- d-dd confining zone
- Deepest (dd-well) ground water zone

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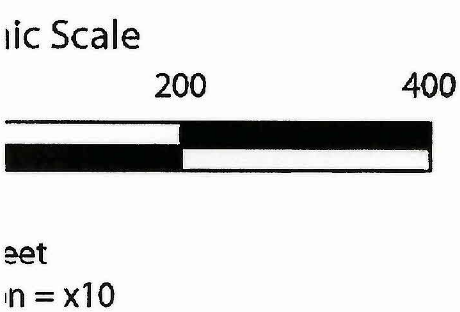
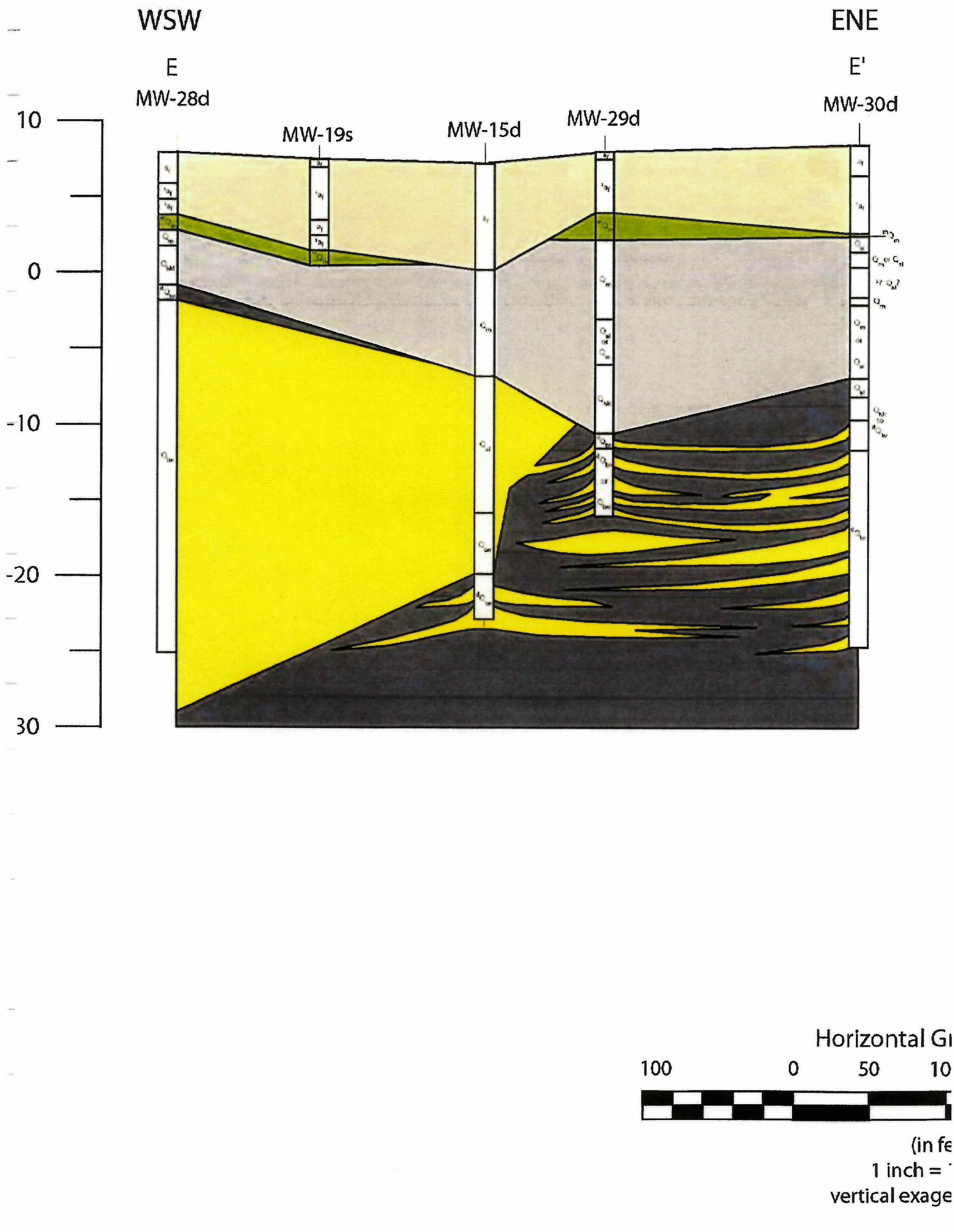
- Glacial Lake Bayonne Distal Delta Deposits
- Glacial Lake Bayonne Bottom Deposits
- Glacial Lake Bayonne Lacustrine Fan Deposits
- Lithologic Contact
- Inferred Lithologic Contact



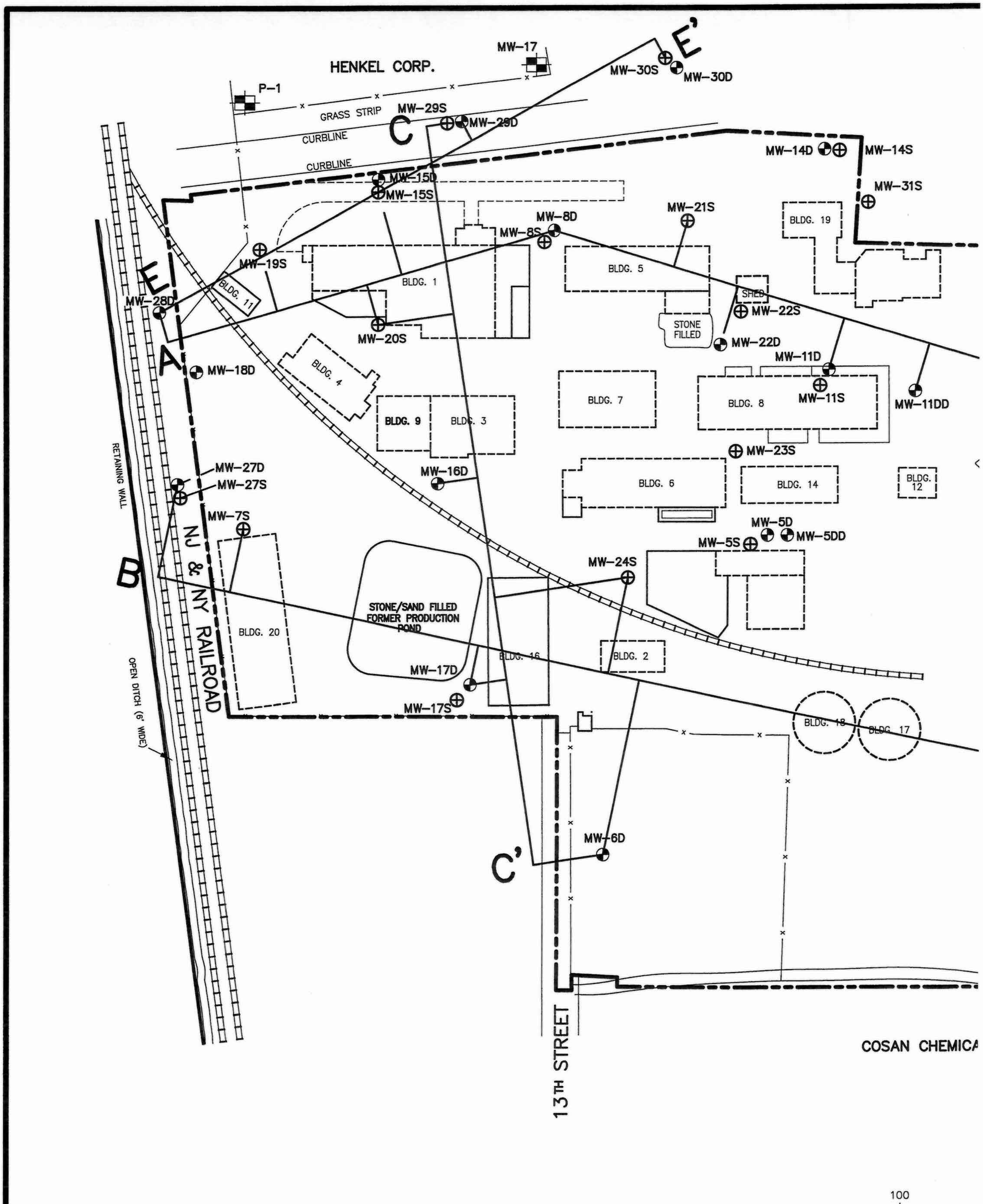
Hydrostratigraphic Cross-Section E

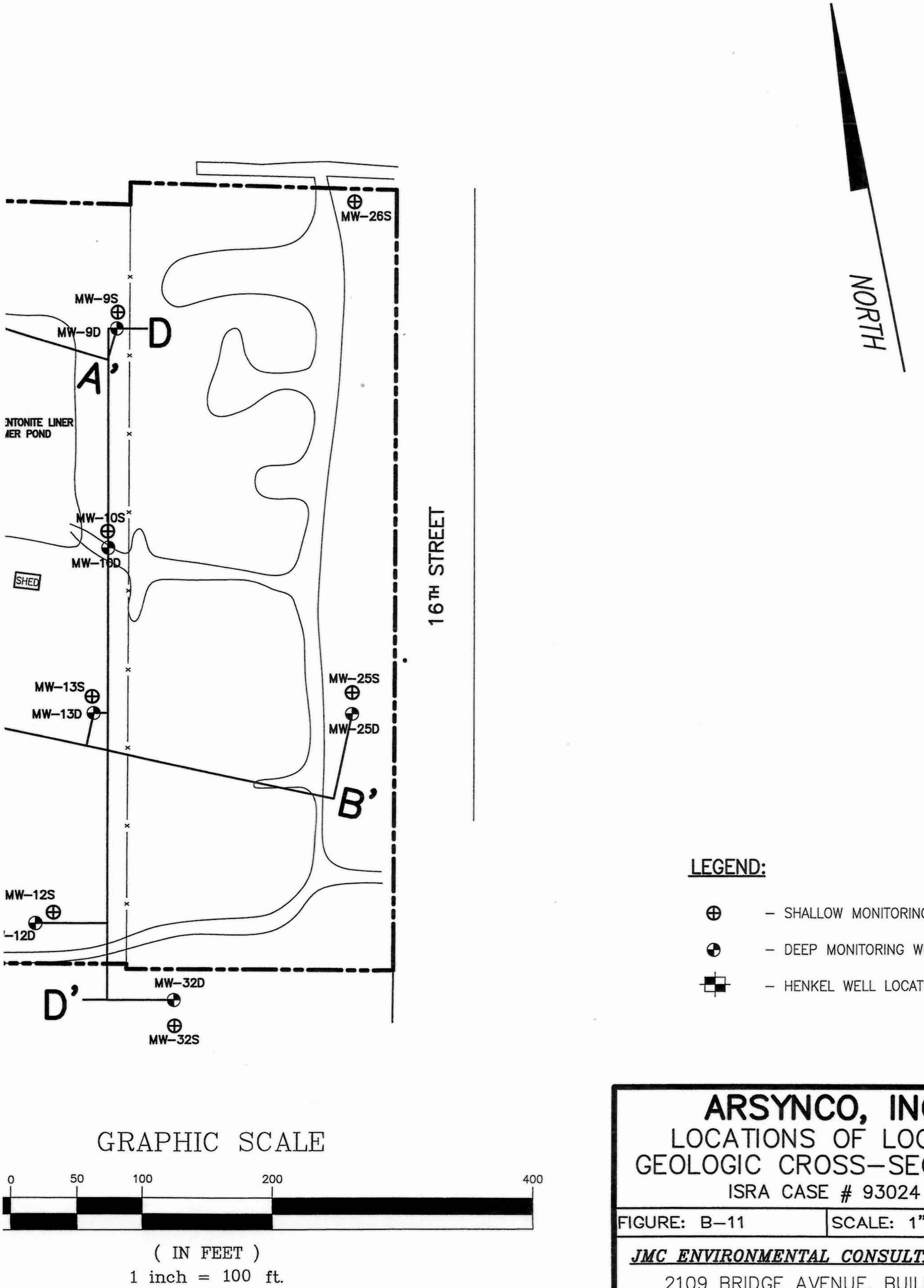
Figure B-10

ARSYNCO SITE
CARLSTADT, NJ



WSW
ENE
E
E'
MW-28d
MW-19s
MW-15d
MW-29d
MW-30d
10
0
-10
-20
30
Horizontal Gı
100
0
50
10
(in fe
1 inch = '
vertical exage


HENKEL CORP.
MW-17
P-1
GRASS STRIP
CURBLINE
CURBLINE
MW-29S
MW-29D
MW-30S
MW-30D
MW-14D
MW-14S
MW-31S
MW-15D
MW-15S
MW-21S
MW-8D
MW-8S
BLDG. 19
MW-19S
BLDG. 1
BLDG. 5
BLDG. 11
MW-28D
SHED
MW-22S
STONE FILLED
MW-20S
MW-22D
MW-11D
MW-18D
BLDG. 4
BLDG. 7
BLDG. 8
MW-11S
MW-11DD
BLDG. 9
BLDG. 3
MW-23S
RETAINING WALL
MW-27D
MW-27S
MW-16D
BLDG. 6
BLDG. 14
BLDG. 12
MW-7S
MW-5D
MW-5DD
MW-5S
NJ & NY RAILROAD
MW-24S
STONE/SAND FILLED FORMER PRODUCTION POND
BLDG. 20
BLDG. 16
BLDG. 2
OPEN DITCH (6' WIDE)
MW-17D
MW-17S
BLDG. 18
BLDG. 17
MW-6D
E
E'
A
B
C
C'
13TH STREET
COSAN CHEMICA
100



ARSYNCO, INC.

LOCATIONS OF LOCAL
GEOLOGIC CROSS–SECTIONS
ISRA CASE # 93024

FIGURE: B–11	SCALE: 1" = 100'

JMC ENVIRONMENTAL CONSULTANTS, INC.

2109 BRIDGE AVENUE, BUILDING B
POINT PLEASANT, NEW JERSEY 08742

JMC2003–6.DWG

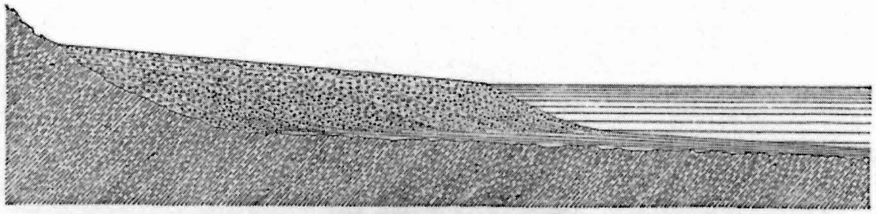


FIG. 4.—Ideal section of a Delta.

Figure B-12. Idealized cross-section of a Gilbert-type delta prograding across lake-bottom deposits. (from Gilbert 1885).

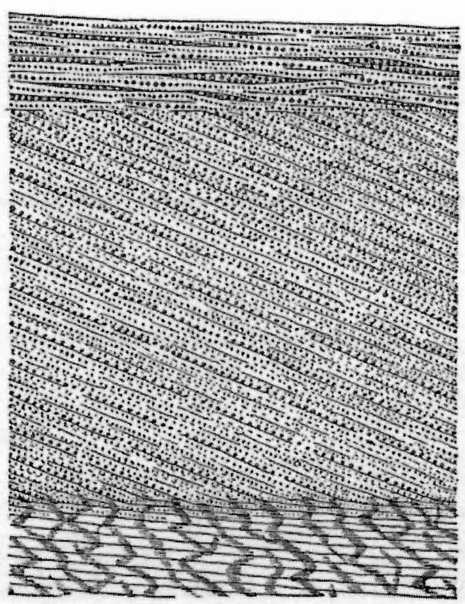


FIG. 5.—Vertical section in a Delta, showing the typical Succession of Strata.

Figure B-13. Succession of strata illustrating the high-angle cross-beds deposited as foreset beds in a Gilbert-type delta. (from Gilbert 1885)

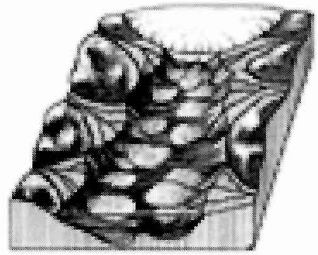


Figure B-14. Three-dimensional pattern of deposition in a glacial lake formed in a glacially scoured valley. (after Ashley 1975).

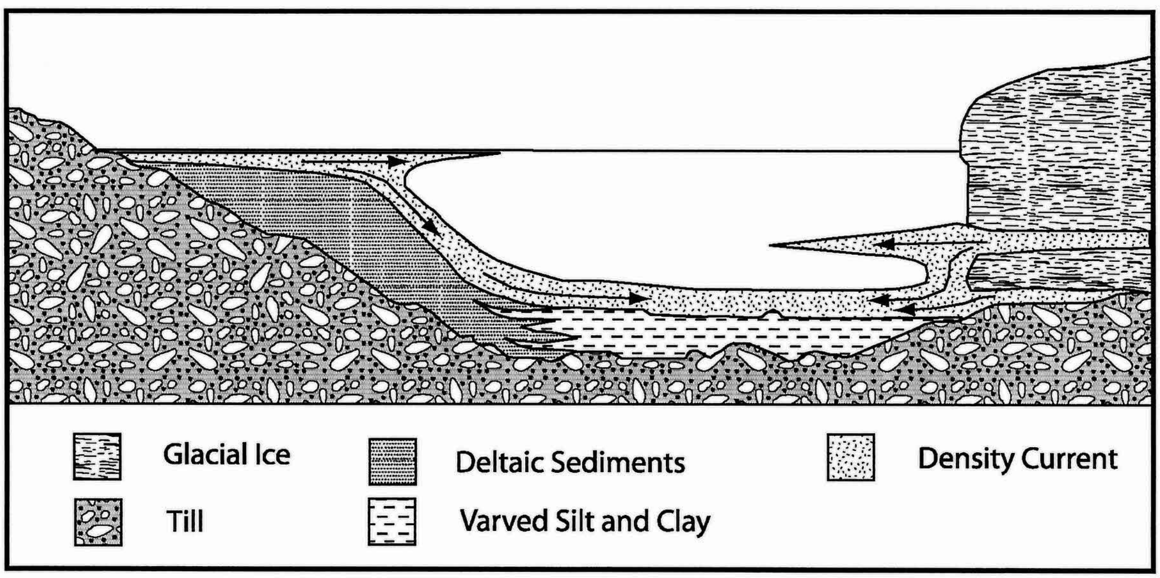


Figure B-15. Deposition from density currents in a glacial lake. (after Gustavson 1975)

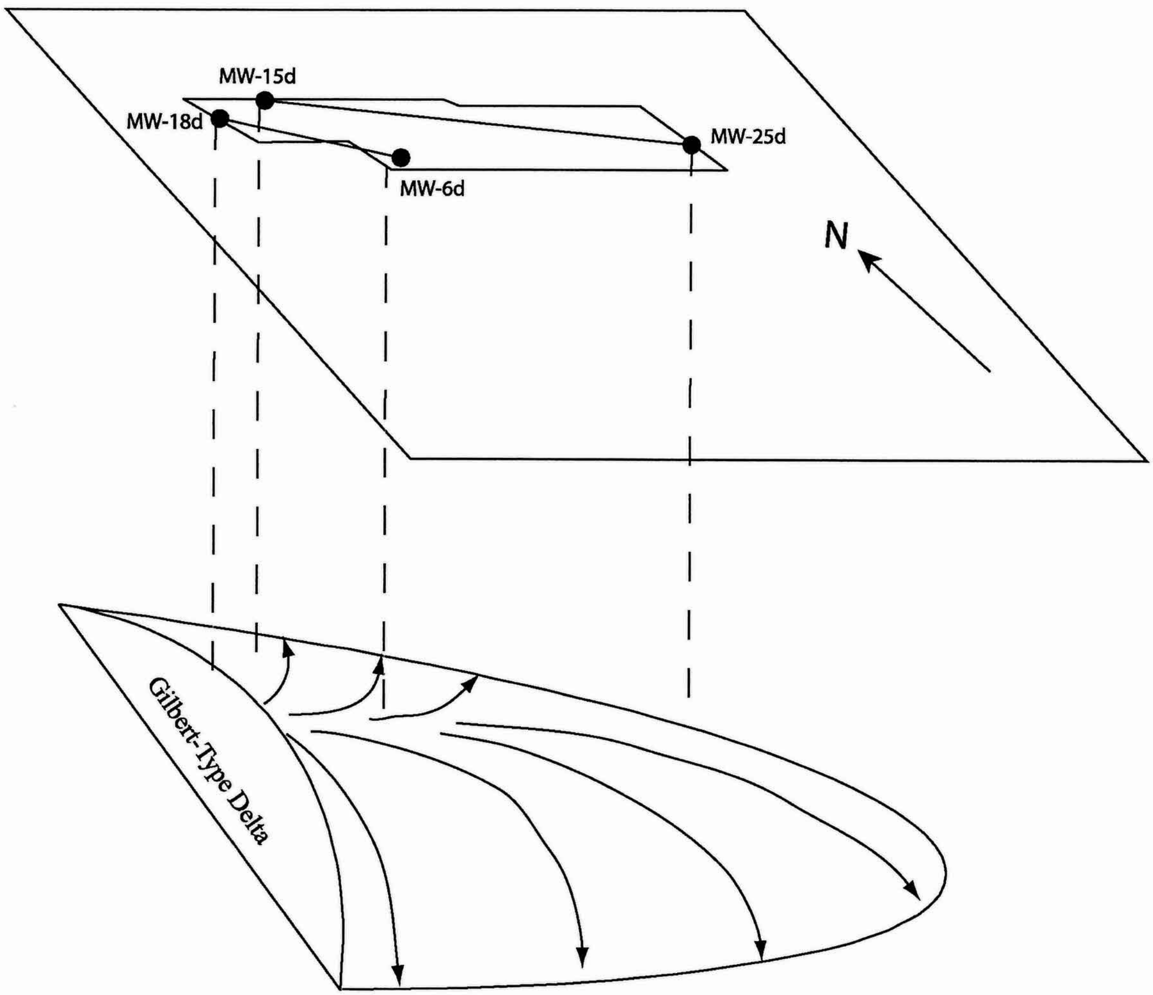


Figure B-16. Schematic illustration showing the location of the Arsynco, Inc. site with respect to the glacial Lake Bayonne deltaic deposit.

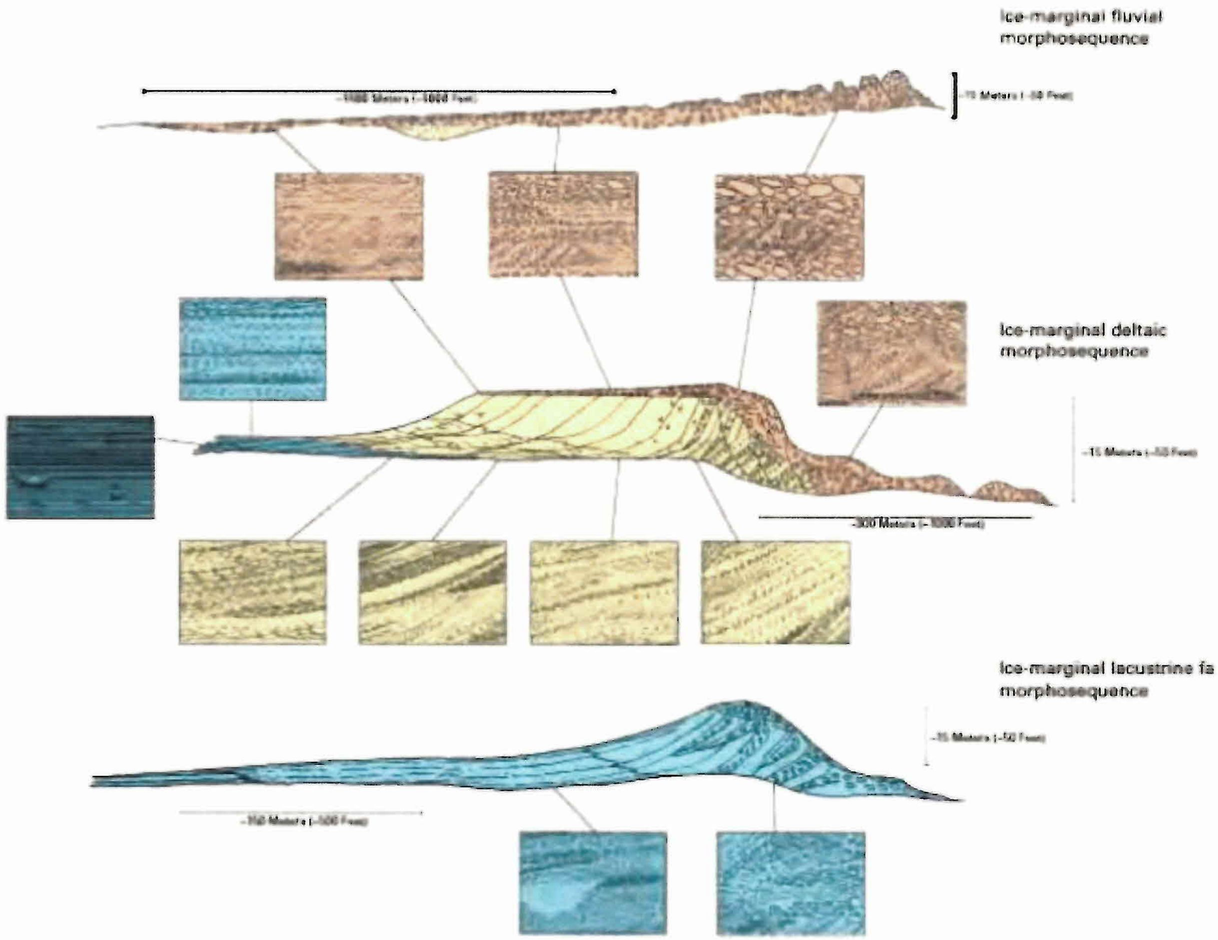


Figure B-17. Schematic illustration showing sub-environements of deposition in glacial lake sedimentary settings.

Figure B-18.

Schematic illustration showing sub-environments of deposition in glacial lake sedimentary settings. (photo courtesy of Dr. Julie Brigham-Grette)

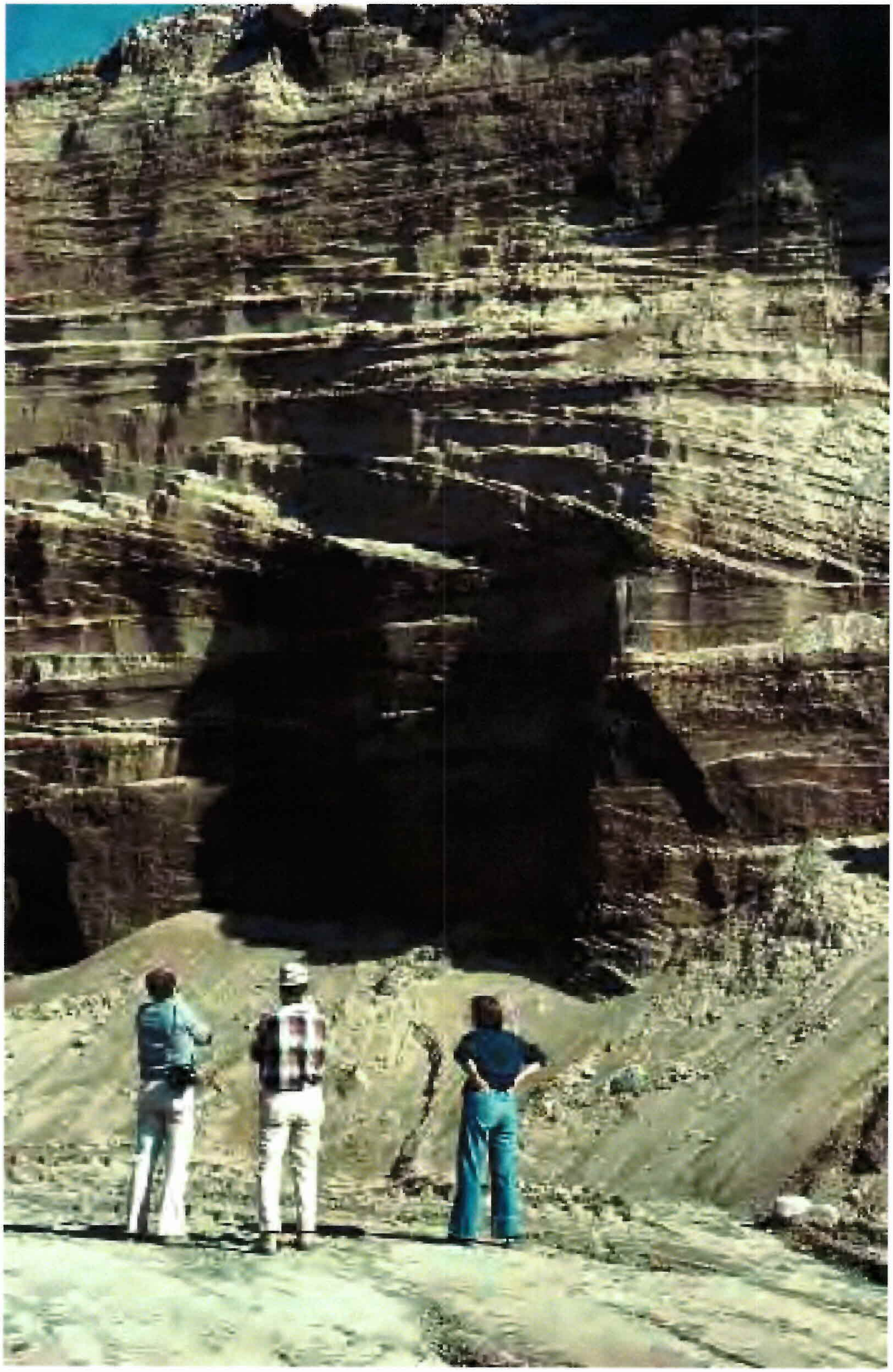


Figure B-19. Steeply dipping foreset beds in a glacial lake delta. (photo courtesy of Dr. Julie Brigham-Grette)

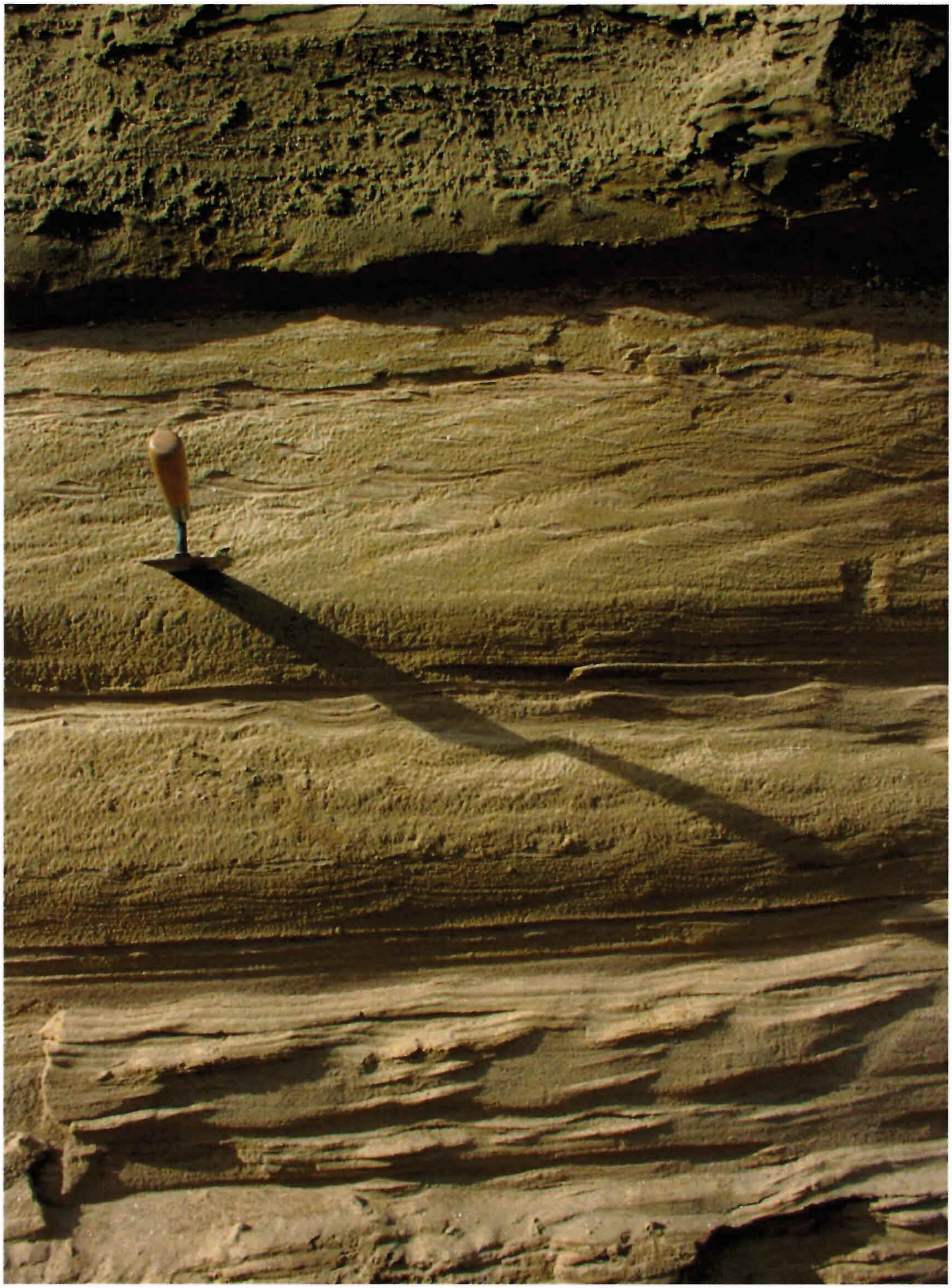


Figure B-20. Laminar and climbing ripple sedimentary structure of fine sand and silt bottomset beds in a glacial lake delta toe setting. (photo courtesy of Dr. Julie Brigham-Grette)

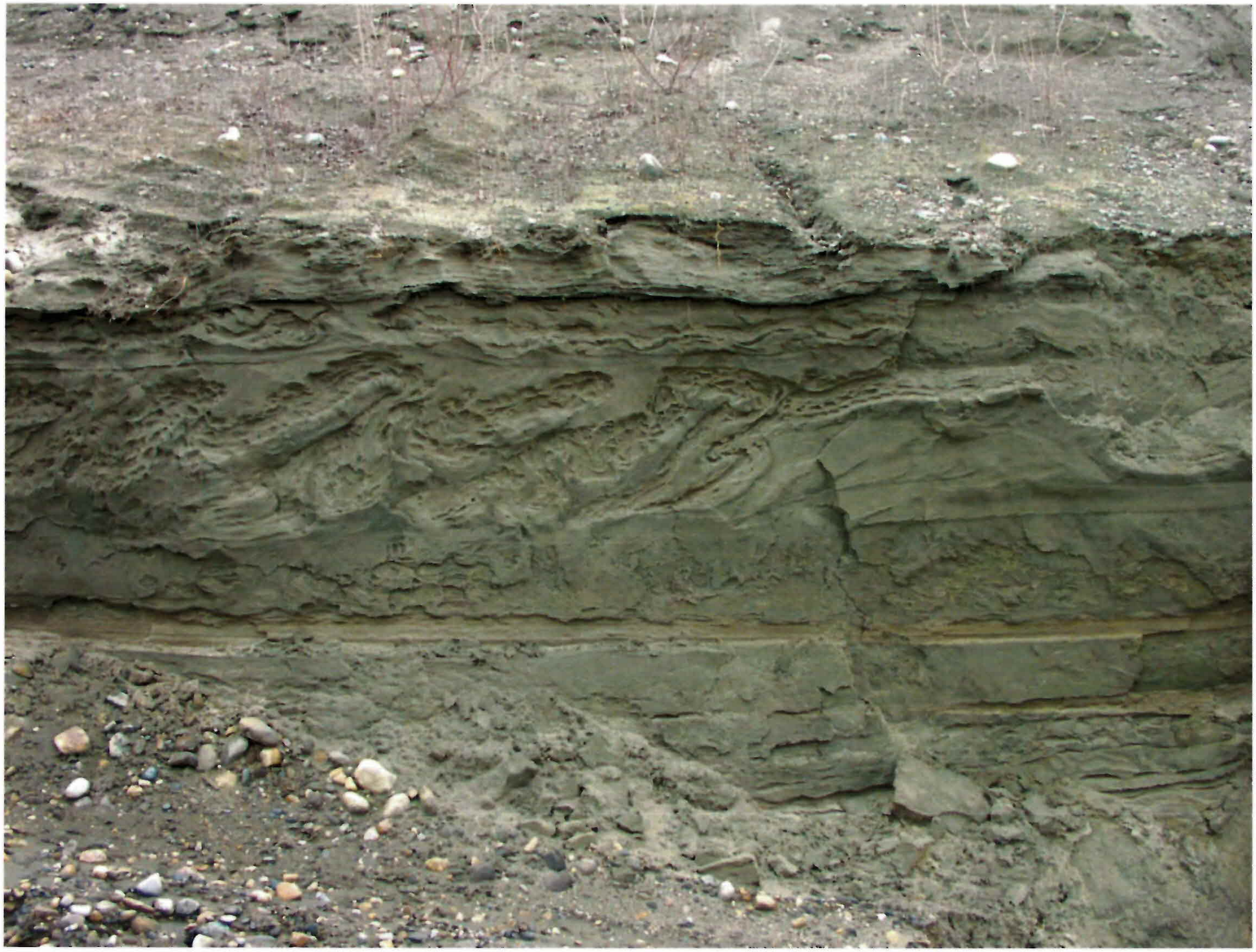
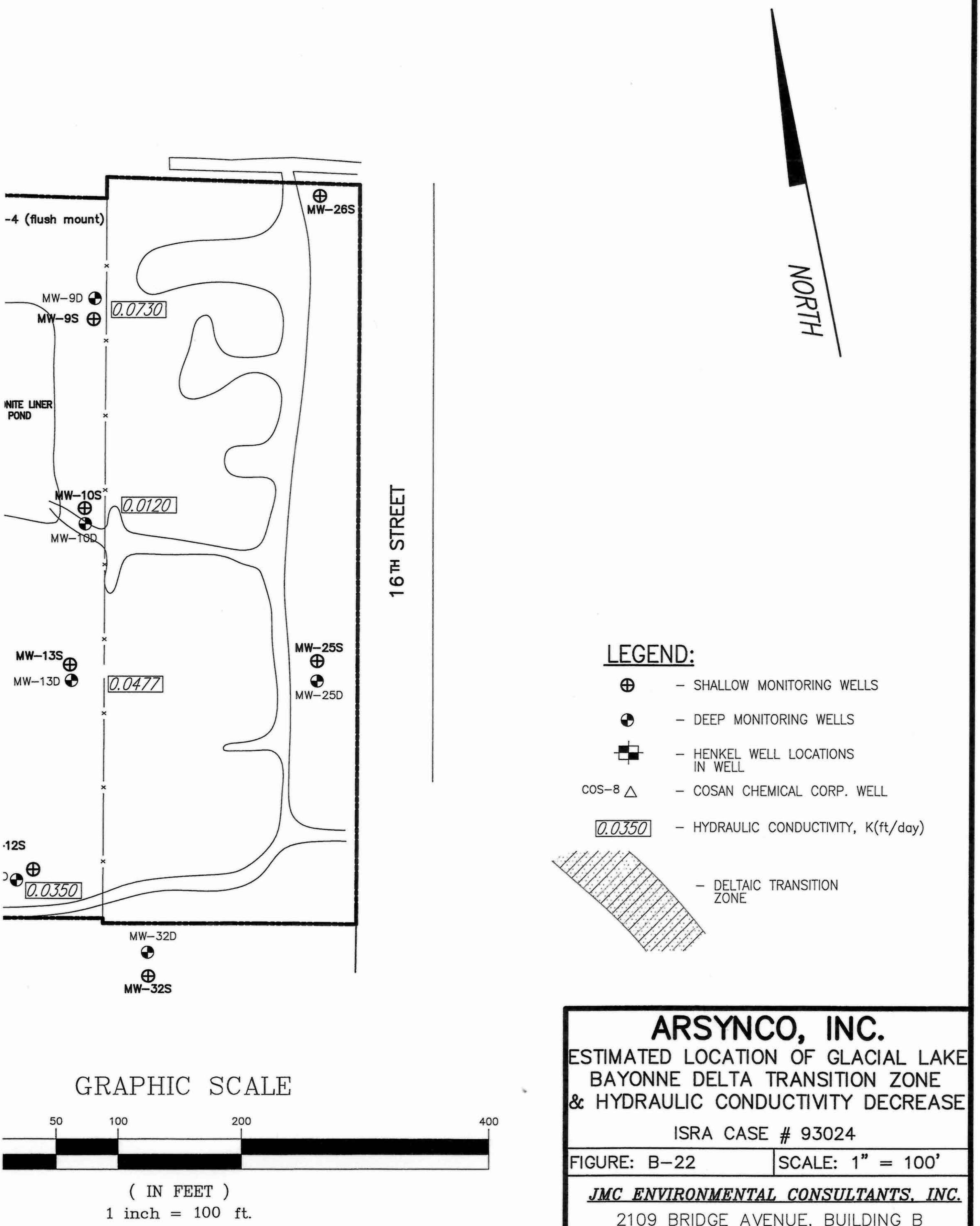


Figure B-21. Dewatering structures in fine-grained sediments of glacial lake delta bottomset beds. (photo courtesy of Dr. Julie Brigham-Grette)



ARSYNCO, INC.

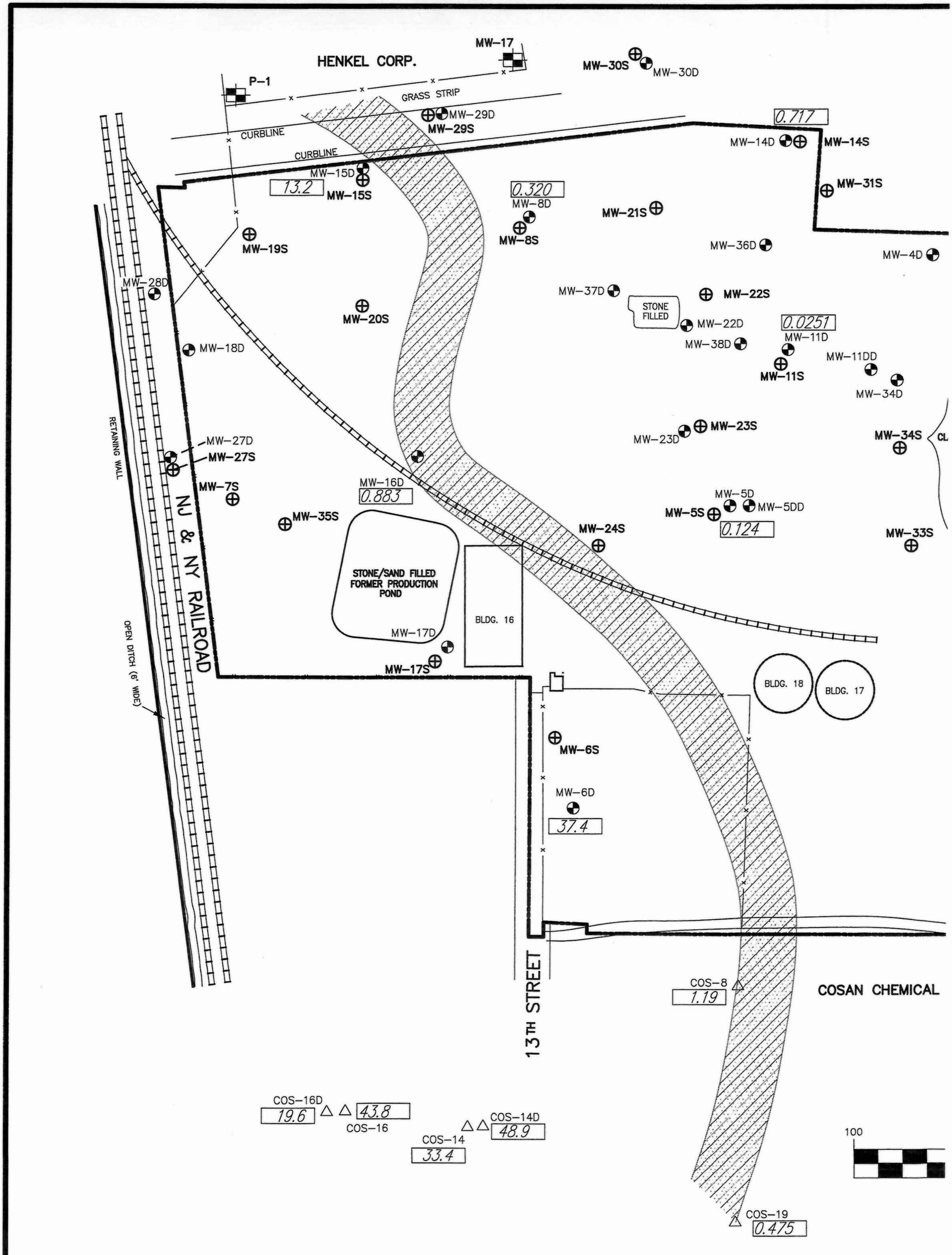
ESTIMATED LOCATION OF GLACIAL LAKE BAYONNE DELTA TRANSITION ZONE & HYDRAULIC CONDUCTIVITY DECREASE

ISRA CASE # 93024

FIGURE: B-22	SCALE: 1" = 100'

JMC ENVIRONMENTAL CONSULTANTS, INC.

2109 BRIDGE AVENUE, BUILDING B
POINT PLEASANT, NEW JERSEY 08742



HENKEL CORP.
MW-17
P-1
MW-30S
MW-30D
GRASS STRIP
MW-29D
MW-29S
CURBLINE
CURBLINE
0.717
MW-14D
MW-14S
MW-15D
13.2
MW-15S
0.320
MW-8D
MW-8S
MW-21S
MW-31S
MW-19S
MW-36D
MW-4D
MW-28D
MW-37D
MW-22S
STONE FILLED
MW-20S
MW-22D
0.0251
MW-11D
MW-38D
MW-18D
MW-11DD
MW-11S
MW-34D
RETAINING WALL
MW-27D
MW-27S
MW-23S
MW-23D
MW-34S
CL
MW-7S
MW-16D
0.883
MW-5D
MW-5DD
MW-5S
0.124
MW-35S
MW-24S
MW-33S
NJ & NY RAILROAD
STONE/SAND FILLED FORMER PRODUCTION POND
BLDG. 16
MW-17D
MW-17S
OPEN DITCH (6' WIDE)
BLDG. 18
BLDG. 17
MW-6S
MW-6D
37.4
13TH STREET
COS-8
1.19
COSAN CHEMICAL
COS-16D
19.6
43.8
COS-16
COS-14D
48.9
COS-14
33.4
100
COS-19
0.475